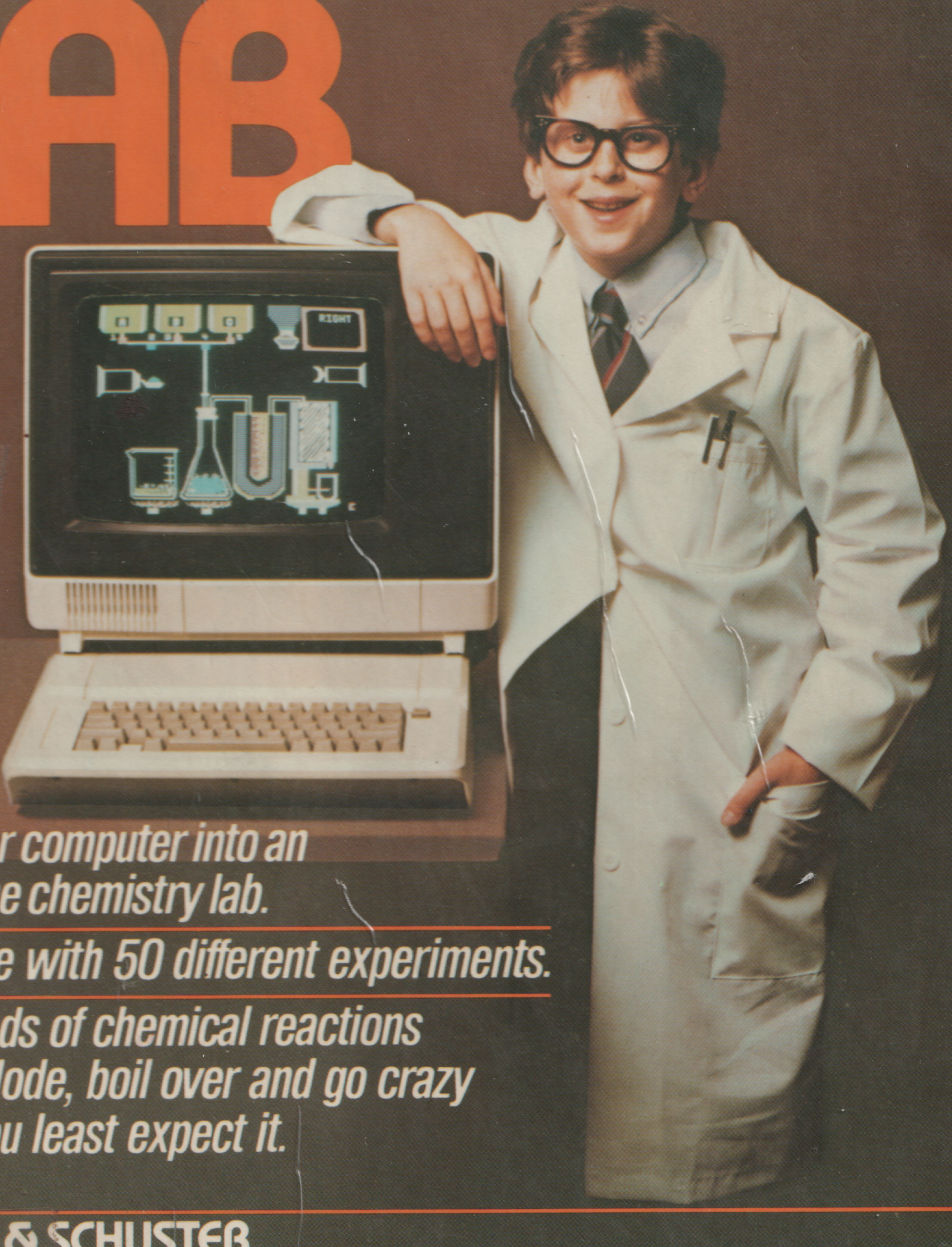
SOFTWARE FOR THE APPLE II+, IIe, IIc, IIGS

CHEM LAB



Turn your computer into an awesome chemistry lab.

Complete with 50 different experiments.

Thousands of chemical reactions that explode, boil over and go crazy when you least expect it.

SIMON & SCHUSTER

CHEM LAB

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Note to New Chemists

Chem Lab is designed to be fun. The user's guide is written for you. Read it and you will learn all sorts of interesting things about the program, chemistry, and science. There are some things you should know about the experiments before you start. All of the experiments could actually happen in real life. But many of them use dangerous or costly materials that usually are not available to the beginning chemist. That means that you can try some things that ordinarily you would not be able to do without your computer. But the dangerous experiments, like the ones that explode, deserve a special note. You can do these experiments inside your computer, but you should not try to do them with real chemicals. The reason is obvious. It is one thing to blow up a computer screen, and another to risk harming yourself and others in real life. So have fun with Chem Lab and your computer, but remember that real chemistry requires many safety precautions and should not be attempted without the proper equipment and training.

Note to Parents and Teachers

Chem Lab puts a chemistry set inside your computer. Young chemists will learn about chemistry and science while they have a good time. The fifty experiments stretch creative powers and provide hours of enjoyment and challenge.

The program contains fifty different experiments with thousands of possible combinations of chemicals. The chemical reactions in the program use authentic chemistry principles and mimic actual reactions that occur in the scientific laboratory. The user's guide is designed to convey important science concepts that are illustrated by the program.

Chem Lab uses the computer to do things that the young chemist could not do in real life. Many of the experiments in the program would be dangerous or use costly equipment or chemicals if done in the laboratory. The computer provides a safe, open-ended environment for young minds to explore. And you don't have to clean up the mess afterward.

Most of all, Chem Lab is fun for your child. It presents science as an adventure. The aim of this program is to capture the interest and excitement of scientific exploration and make this excitement accessible.

MIND OVER MATTER

This is your big chance. You can prove to your parents how smart they were to invest in a computer. Chem Lab is like no other program you or they have ever seen. Once you get into it, you will discover things that even you thought were impossible to do on a computer. Chem Lab enables you to play with matter in ways you never dreamed of and solve mind-boggling mysteries. Best of all, it has been cleverly designed to make it look as though you're learning something, while you're really having fun.

Here are a few basics to get you started and to help you convince your friends, parents, and anyone else who might be interested that this game is both educational and fun. Flash a few of these facts at dinner, and your folks will probably nod and smile. But they'll never suspect what a good time you're having!

Chem Lab Facts

Fact #1 Everything in the world is made of matter, from your old blue jeans to the big blue sea.

Fact #2 All matter is made up of about one hundred basic chemicals, called *elements.*

Fact #3 Everything (yes, *everything*) can be made by combining these elements in different ways to make chemicals, which make—you guessed it—matter!

And that's what chemistry is all about.

Fact #4 Take the chemicals in your body, for instance. Theoretically, by mixing and rearranging them, you could create almost anything—from a redwood tree to a black leather jacket. But it's a little impractical—not to mention messy—to try this in your living room.

Fact #5 That's where Chem Lab comes in: You can perform experiments with your trusty computer, and this program does all the dirty work for you. You don't have to worry about dissolving the cat or blowing up the new drapes. That should save you a few hassles!

Try it and see. Choose an experiment. Mix some chemicals. Heat them, pressurize them, and watch what happens. They might give off waves of heat or light; they might crack a glass or even cause an explosion—on your computer screen, that is.

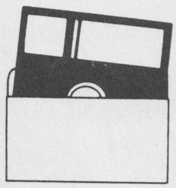
Get ready. You'll need every ounce of brainpower you can find. But just between you and your computer: The main thing is to have fun and see what you can discover. Pretty smart, huh?

And your parents will think that all you're doing is improving your mind!

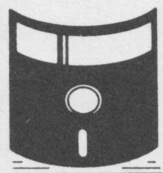
STARTING INSTRUCTIONS

Removal and Care of the Diskette

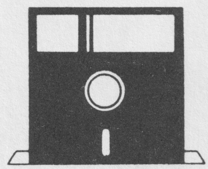
Remove the diskette from the envelope in the back of this manual. When not using the diskette, return it to this envelope for safekeeping. The diskette is magnetic and should be handled carefully. Placing it on or near anything magnetic could erase information. This includes such objects as a loudspeaker, kitchen appliance, or paper-clip holders. And let's not overlook the most common crime against diskettes—leaving them lying on top of a computer or monitor. These may seem like convenient places, but in fact may damage the diskette. Also, don't touch the surface of the diskette itself (the platter inside the protective sleeve), don't bend it, and avoid temperature extremes.



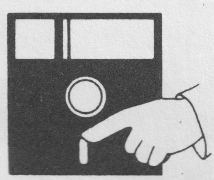
Store Properly



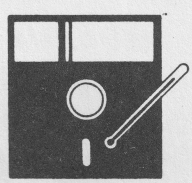
Don't bend



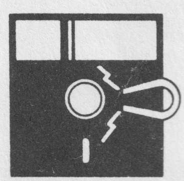
Insert Carefully



Don't touch exposed surface



Store at 10°C-53°C 50°F-125°F



Keep away from magnetic fields

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Loading Chem Lab

On Your Apple

- Turn off your computer.
- Insert the diskette, side 1 up, into the disk drive and close the drive door.
- Turn on your computer.
- The program will load and the title screen will appear.
- Go to "On the Level" (p. 9) or "Quick Start" (p. 7) in this manual to continue.

On Your IBM

- Insert PC-DOS 2.0 or 2.1 into drive A and close the drive door.
- Turn on your computer.
- When "A" appears, insert the disk and type **CHEM LAB**.
- Press ENTER.
- The program will load and the title screen will appear.
- Go to "On the Level" (p. 9) or "Quick Start" (p. 7) in this manual to continue.

On Your Commodore

- Turn on your computer and disk drive. (If you have a 128, type **GO64** and press RETURN. When "ARE YOU SURE?" appears, type **Y** and press RETURN.)
- Insert your disk, side 1 up, into the disk drive and close the drive door.
- When you see the word "READY," type: **LOAD "CHEM LAB",8.**
- Press RETURN.
- When you see the word "READY" again, type: **RUN**.
- Press RETURN.
- The program will load and the title screen will appear.
- Go to "On the Level" (p. 9) or "Quick Start" (p. 7) in this manual to continue.

On Your Atari

- Turn off your computer and disk drive.
- Insert the diskette, side 2 up, into the disk drive.
- Turn on your disk drive.
- Turn on your computer holding down the OPTION key.
- The program will load and the title screen will appear.
- Go to "On the Level" (p. 9) or "Quick Start" (p. 7) in this manual to continue.

Quick Start

These instructions tell you how to get the program going quickly. But be sure to read the rest of this manual, including "On the Level" (p. 9) and "Choose Your Experiment" (p. 11), to learn all the details you will need to make the most of Chem Lab.

Step 1 Load the program using the instructions for your computer on page 6.

Step 2 After the title screen goes by, you will see the "EXPERIMENTS" screen. Press the space bar until you see the experiment you want to do. (There are fifty experiments. These are listed and described in "Chem Lab Log," p. 41.)

Step 3 Decide which experiment you want, and then press RETURN or ENTER (↵).

Step 4 Type the name of the experiment and press RETURN or ENTER (↵).

Step 5 A screen with your goal and raw materials will appear. After you check out this information, press RETURN.

Step 6 The Lab Screen will appear. Go to it!

Keyboard Controls

Once you are in the lab you can see a list of keyboard commands on-screen by pressing the question-mark (?) key. The list has two parts; press the space bar to see the second half of the list. Then press any key to remove the list.

Here is the same list of keyboard commands you will see on the screen with a little more explanation:

O → OTHER ARM	Switches the active robot arm from left to right or vice versa. Checks the monitor to see which one is active.

S → SOLIDS	Lists the chemical solids available in the experiment.
L → LIQUIDS	Lists the chemical liquids available in the experiment.
G → GASES	Lists the chemical gases available in the experiment.
B → BURNERS	Press B to obtain or extinguish a Bunsen burner. (More commands on p. 30.)
V → GAS VALVES	Press V to find out which valves are open and closed. (More commands on pp. 29-30.)
C → CLEAR LAB	Clears all equipment from lab and starts your experiment again; you stay in the lab.
T → TARGET	Tells you the name of your target substance—the chemical you are trying to make.
ESC → ESCAPE	Ends the experiment and returns you to the "EXPERIMENTS" screen. (On a Commodore use the CLR/HOME key.)
RETURN → OPERATE HAND	Operates the hand of the active robot arm and tells the computer to accept information you have typed in.
E → EQUIPMENT	Lists all the equipment available in the Chem Lab basement.

H → HEAT CHAMBER	Turns the heat chamber on or off.
P → PRESSURE CHAMBER	Turns the pressure chamber on or off.
SPACE BAR → REPLACE HAND	Changes the hand on the left robot arm from scoop to spigot to cork.
M → READ MESSAGE	When you create a chemical reaction, the words "REACTION MESSAGE" will appear on the monitor. Then press M to see what chemicals you have created and how they relate to your goal.
R → REVIEW EXPERIMENT	Takes you back to the Goal screen. Once you press R, you have to start the experiment over again from the beginning.

No command will work while any list is on the screen. To remove a list, press any key. Then proceed.

If you make an error when you type something in, you can remove it by pressing the left-arrow cursor key.

Remember, Y means yes, N means no. You'll need them to answer questions on the screen.

On the Level

After you start the program and the title screen goes by, the "EXPERIMENTS" screen appears (see Figure 1, p. 10). Check it out. All fifty of the Chem Lab experiments are listed on this screen. (They're also listed in the "Chem Lab Log" on p. 41.)

- Press the space bar to see the names of all the experiments you can do. There are fifty in all. Pressing the space bar five times will

Figure 1
Experiments screen

EXPERIMENTS

NAME	LEVEL
DRINK ME	1
GET WET	1
OVER THE RAINBOW	1
LOAD THE DRYER	1
PINCH-HITTING	1
WHAT A GAS!	1
CHALK IT UP	2
DRINK UP!	1
RATS!	2
CAUGHT RED-HANDED	2

..PRESS SPACE BAR TO SEE MORE NAMES...

.....PRESS RETURN TO CHOOSE ONE.......

show you all the experiments. After that the list scrolls through again.

Each experiment has its own level of difficulty, labeled 1, 2, or 3 to its right on the screen. Level 3 is the most difficult. Choose carefully. This way, you won't get in too deep before you have a chance to learn your way around. So before you settle on the one you want to try, decide how handy you feel around a lab. Here's a look at how each level works:

Level 1: Lab Assistant

A great place to get started. Your experiments will be simple, but their reactions are powerful and may surprise you.

Level 2: Chemist

You know the basics, and you're ready for action. Here's a chance to tackle some more ambitious assignments.

Level 3: Nobel Prize Winner

Madame Curie and Dr. Linus Pauling welcome you to the ranks: You're a real pro! Brace yourself for what's ahead. You'll need every beaker, burner, and bit of brainpower you can muster for these experiments, some of which have more than one part to them.

Choose Your Experiment

You know the level you want to choose and you're ready to roll. You've cased all your choices, but which one will it be?

- Press the space bar until you see the name of the experiment you want to try. Check the level number next to its name to make sure it's on the right level.
- Then press RETURN. Chem Lab will ask you which experiment you want.
- Enter the *complete name* of your experiment. Be sure to spell it correctly, exactly as it is on the screen.

Here's an example. After you press RETURN the program will ask: "WHICH EXPERIMENT?→." Type **DRINK ME**. It will look like this:

Figure 2

Choose Drink Me

```
              EXPERIMENTS
     NAME                       LEVEL

     DRINK ME                     1
     GET WET                      1
     OVER THE RAINBOW             1
     LOAD THE DRYER               1
     PINCH-HITTING                1
     WHAT A GAS!                  1
     CHALK IT UP                  2
     DRINK UP!                    1
     RATS!                        2
     CAUGHT RED-HANDED            2

WHICH EXPERIMENT?-> DRINK ME
```

Make sure that you enter the experiment name exactly as you see it. Then you can't go wrong! If you make a mistake as you enter your experiment name, press the left-arrow cursor key to erase the errors. (On a Commodore use the INST/DEL key.) Then make whatever correction you need.

- Now press RETURN and the program will load your experiment into the computer's memory. If you made a mistake and didn't catch it, just try again.

Goal Screen: Target and Raw Materials

Figure 3

Goal Screen for Drink Me

```
1                  :DRINK ME
                   :---------------------
YOUR GOAL IS       :TAKE A PINCH OF
TO PRODUCE         :POWDERED BASEBALL,
                   :ADD A SPRITZ OF
MAGIC ELIXIR       :SUPERNOVA JUICE...
                   :GIVE IT A BURST OF
                   :FRESH ALASKAN GAS AND
STARTING WITH THE  :CORK UP! NOW HEAT
FOLLOWING RAW      :THIS MAGICAL MIXTURE
MATERIALS:         :AND YOU'VE MADE THE
                   :FABULOUS CHEM LAB
(S)POWDERED        :COCKTAIL. BUT WATCH
   BASEBALL        :OUT -ONE SIP GOES A
(S)BUBBLEGUM       :LONG WAY!
(L)SUPERNOVA JUICE:
(L)SODA POP        :
(G)ALASKAN GAS     :
                   :
                   :
                   :
                   :
                   :

   PRESS RETURN TO DO THE EXPERIMENT
```

General Description

This screen presents a brief summary of the challenge that lies ahead. It contains the information you need to do the experiment. Read it and keep the information in mind as you mix and match chemicals.

If you forget what's going on while you're in the middle of your experiment, you can return to the Goal Screen at any time by pressing R for review. You can also find a description of each experiment in the Chem Lab Log, beginning on page 41 of this book. Refer to the log to review your target substance or your choice of raw materials as you do your experiment.

Target Substance

On the left side of the Goal Screen, you'll find the number of the experiment you have chosen, and the target substance for this experiment—usually along with its chemical formula. The target substance is the chemical you are trying to create by mixing the raw materials together and doing all sorts of weird things with them. The target is labeled (S), (L), or (G) to tell you its state—solid, liquid, or gas—at room temperature. The chemical formula will give you some hints about which things might make up the target. (Take a look at the list of chemical formulas on page 59 for more hints.)

Raw Materials

Also on the left side of the Goal Screen are listed the raw materials available to perform the experiment. In each experiment you always have four, five, or six raw materials to use. They are labeled (S), (L), or (G) for solid, liquid, or gas. You can mix them any way you want, to see what happens. Sometimes you'll get a reaction, and sometimes you won't. In each experiment, there is only one chemical combination that will react to give you the target substance, but lots of combinations will do interesting and surprising things.

Take a good look at this information. Everything you need to know to solve the experiment is in front of you. You can use either chemical formulas or the names of the chemicals when you are doing the experiments. (And of course, there's information here that you can also use to impress your friends and family. Next time you're at dinner ask someone to pass the NaCl or offer to bring someone a glass of H_2O.)

Look Again

Take one more good look at the information on the Goal Screen to be sure you have it down. If you need to see it again during the experiment, here's how:

- Press R to review the Goal Screen while you're in the lab. You may need a reminder of your goal or the chemical formula for the target substance. *Remember*, though, if you press R, you will have to start the experiment over again.

When you are in the main lab you may also:

- Press T to see the target substance. Then press any key to remove the message and go back to the experiment.
- Press S to see a list of solid raw materials available. Press any key to remove this list. Pressing L and G will show you the liquids and gases, in the same way.
- Press C to clear the lab of all equipment and start the experiment over again.

Now if you're ready for the big mix, press RETURN to go on.

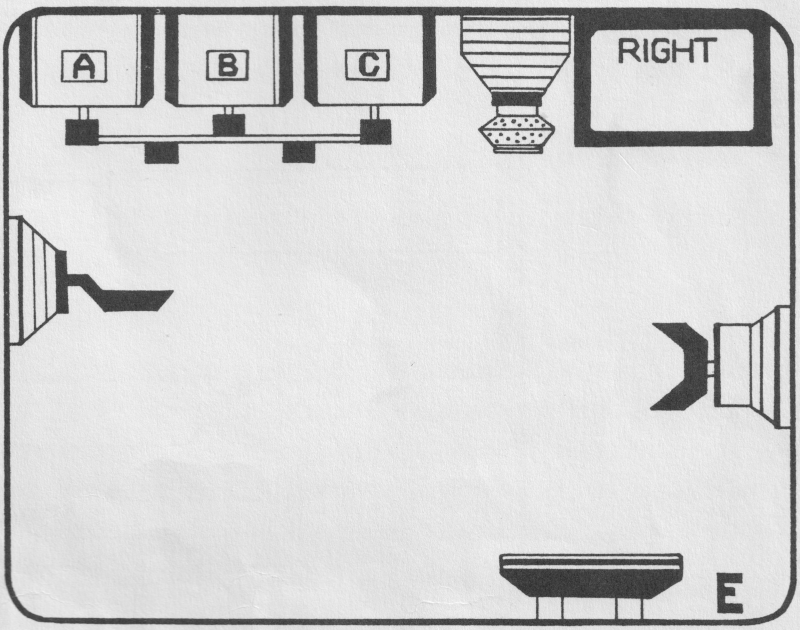
THE MAIN LAB

At last—you're where it's at. You've arrived in Chem Lab. Welcome. You know what elusive chemical compound you have for a target, so now you can try your hand at this chemistry stuff.

Take a chance. Mess around. If anyone asks, say you're "experimenting." You won't blow anything up. Or will you?

In your lab you'll find all the equipment you need to meet any challenge or do any experiment. On the following pages are some things you will need to know to make the lab work for you. Try them out as you read along.

Figure 4
The main lab



Don't Let the Heat or the Pressure Get to You!

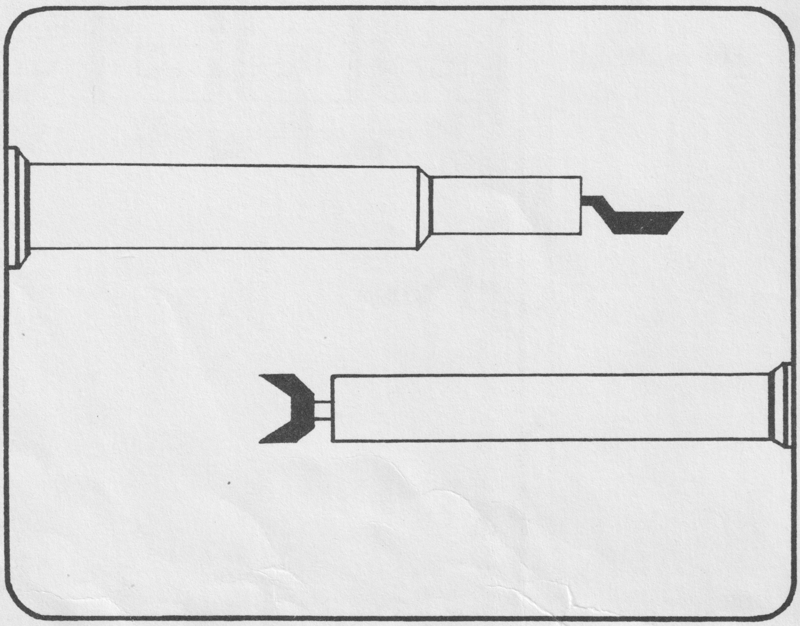
Some experiments may require special lab conditions, such as extraordinary heat or pressure. No sweat! You can customize your lab:

- Press H to *superheat* your lab. Heat waves will radiate from the ceiling. When it's hot enough, a message will appear: "CHAMBER SUPERHEATED."
- Press H again to go back to your experiment and back to normal room temperature.
- Press P to *pressurize* your lab. Panels of pressure will ripple along the lab wall, and then this message will appear: "CHAMBER PRESSURIZED."
- Press P again to get back to work at normal pressure.

Welcome with Open (Robot) Arms!

Take a good look around. You have two very able lab assistants. The pair of *robot arms* (at left and right) will give you a hand—or four!—if you let them.

Figure 5
Robot arms



Activating the Arms

You have two arms in the lab, but you can activate only one at a time. To find out which arm is active, check the Chem Lab *monitor* at the top right-hand corner of your lab screen. The word "RIGHT" or "LEFT" will be displayed there to tell you which arm is active.

- Press the letter O to switch from one arm to the other. Each time you press O, the monitor will tell you which arm is ready to reach.

As you will soon see, each arm performs its own special tricks for you, so it's essential to know how to get to the one you need when you need it. There is nothing more frustrating than forgetting where your arms are!

On the Move

Now try some tests to see how far your arms will stretch.

- Press the right-arrow cursor key to move the arms right, and the left-arrow cursor key to move them left.
- Press the up-arrow cursor key or the letter U to move the arms up, and the down-arrow key or the letter D to move them down.

Let's take them for a spin around the lab and see what they really can do.

- First, make sure that the left arm is active. The monitor should say "LEFT". Press the right-arrow cursor key. Your left arm will extend one unit to the right. Now hold the right-arrow cursor key down, and watch that arm telescope! Ready to pull back? Hold down the left-arrow cursor key, and the arm will shrink back to its starting size.
- Now do the same for the right arm.

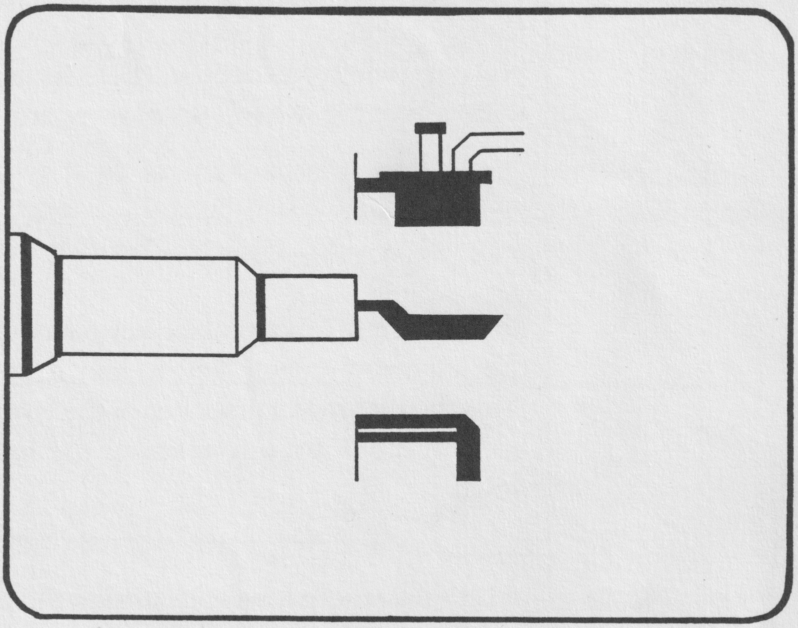
- Now, try pressing the up-arrow and down-arrow (or U and D) for each arm. The left arm can go down only about halfway. The right arm goes all the way up or down.

The arms will go almost anywhere under your control. They certainly get around.

The Hand-Off

Each robot arm has its own special "hands." Your left arm has three hands: a *cork*, a *scoop*, and a *spigot*. Press the space bar to see them.

Figure 6
The three hands of the left robot arm



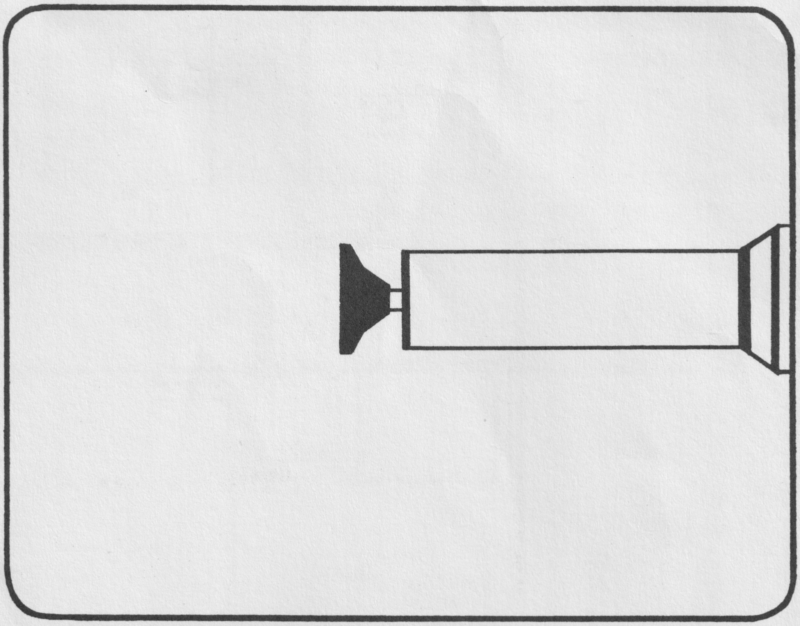
Your right arm has a single hand: a *gripper*.

You will soon have a chance to really use these arms. But first you need a reason to use them. So now let's look at some lab equipment.

Tools of the Trade

Okay. You've got it. There's some pretty weird-looking stuff around this lab, but you think you've figured it out. Some of it must hold chemicals—right?!

Figure 7
The gripper of the right robot arm



First, a basic fact about chemicals: They come in three forms—solid, liquid, and gas. However they come, you can handle it in your lab.

Gas Dispensers

The three dispensers at the top of the lab, labeled A, B, and C, store the gases you will need for your experiment (see Figure 8). There are also five *valves* (numbered 1 to 5) which control the flow of these gases out of their containers and into other equipment.

- Press G. A list of gases will appear. These are the gases available for the experiment you have chosen. (They are the same ones listed on the Goal Screen and in the Chem Lab Log.) The letter next to each gas tells which container it is stored in. You can use any or all of them in the experiment. Press any key to remove the list. To make the gases flow out of the containers, you must open the correct combination of valves. For a detailed description of how to do this, see pages 29-30.

Figure 8
The gas dispensers

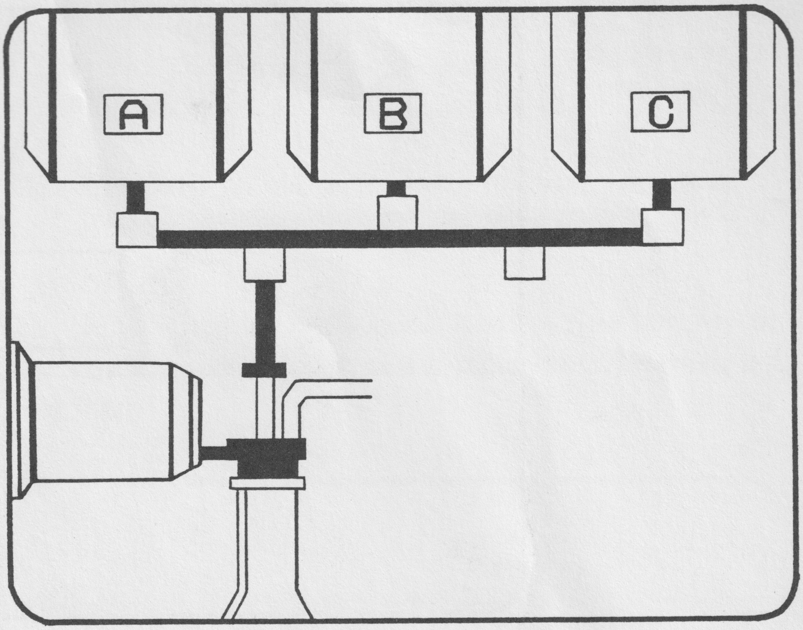
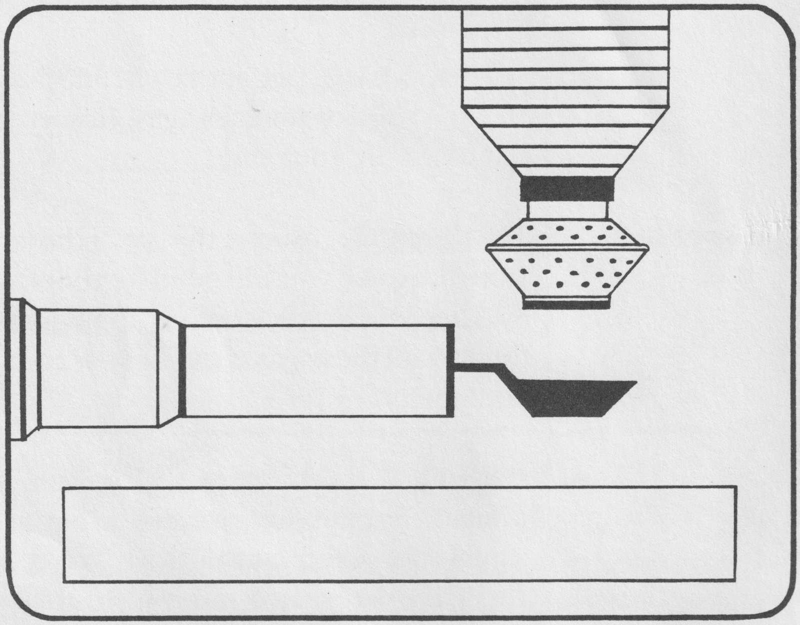


Figure 9
The solids dispenser



Solids Dispenser

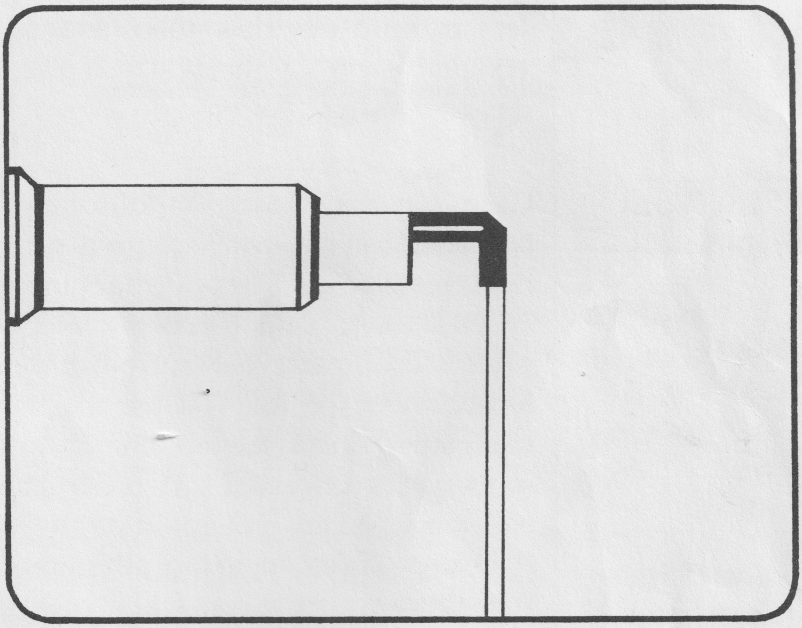
To the right of the three gas dispensers, the solids dispenser stores and supplies all of the solids for your experiment. Without leaving the main lab, you can find out which solids are available.

- Press S and a list of all the solids in the experiment will appear. You can use any or all of them in the experiment. Press any key to get rid of this list.

Liquids Dispenser

Chem Lab stores all liquids in the same place: the spigot hand of the left robot arm. As with gases and solids, you can easily learn which liquids are available to you.

Figure 10
The liquids dispenser



- Press L. The list of liquids will appear. You can use any or all of them in your experiment. Press any key to get rid of this list.

Chem Lab Monitor

To the right of the solids dispenser, the lab monitor keeps you in the know in a couple of ways. It will tell you which robot arm is active: the word "LEFT" or "RIGHT" will appear. And with each chemical reaction you make, the words "MESSAGE" or "REACTION MESSAGE" will appear on your lab monitor along with some sounds or music. When that happens, do this:

- Press M, and you'll see what's up—or what's blown up, in some cases!
- Then press RETURN to get back to your experiment.

Robot Arms

Ah yes, that trusty pair of robot arms: What would you do without them? Not much. What you can do with them, though, is a lot, as you will see.

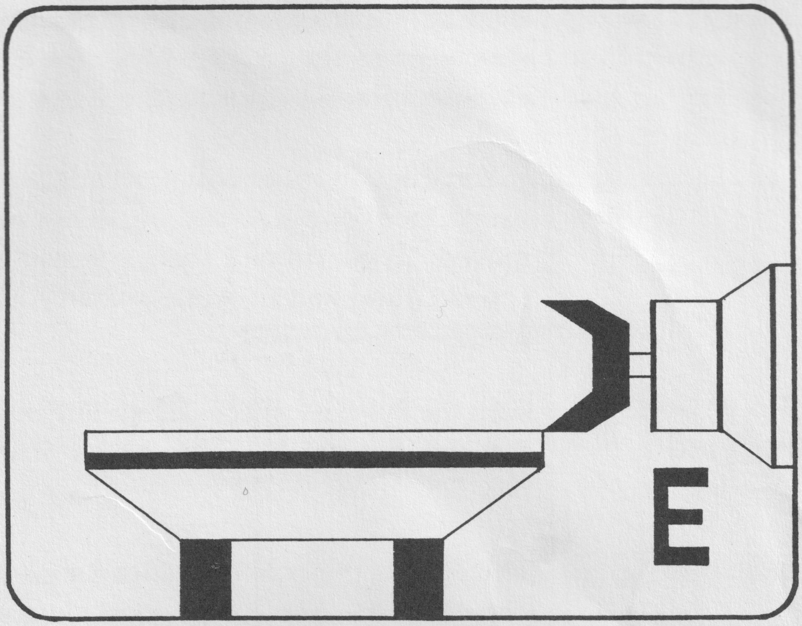
The left robot arm helps you gather and combine the chemicals you need. We'll get to that in a little while. But now let's exercise that right robot arm. It brings you all your equipment and puts things in their places. It's ready when you are, so let's get moving!

Getting Your Equipment

Chem Lab has a basement full of equipment for holding, collecting, drying, and liquifying your mix of chemicals.

- First, Press E to see a list of all the equipment available to you: "FLASK, BEAKER, COLLECTOR, CONDENSER, DRYER." Decide which piece of equipment you want to start with. Then press any key to get rid of the list. You use the right robot arm to get equipment. Check the lab monitor to make sure the right robot arm is active. If it isn't, press O and the word "RIGHT" will appear on the monitor. If you need to, you can use the right-arrow cursor key to move the arm all the way to the right.
- Press the down-arrow cursor key (or D) to move the right arm down, until it rests on the "E" by the *equipment platform* in the lower right-hand corner of the lab. This must be the place! By moving the right robot arm down to this platform, you can get any piece of equipment from the Chem Lab basement.
- When the arm is all the way at the bottom, it "locks into" the platform in the ready position and you are asked which piece of equipment you want. Press E to see a list of all the equipment available to you. Then press any key to get rid of the list.
- Enter the name of the piece of equipment you want. Make sure to spell it right, or you'll have to enter it again! Then press RETURN.

Figure 11
The equipment platform



Presto! The platform will disappear into the basement of the lab and return with your piece of equipment.

See "Fully Equipped" just below and "On Your Own: Terms" (p. 55) for more information of the use of each piece of equipment.

- Use the robot arm to place your equipment where you want it. First press the left-arrow cursor key once to move the arm *one step* to the left. (It's important to move it only one step here.) Next press RETURN, and the gripper will attach itself to the piece of equipment.
- Now press the left-arrow cursor key again to move the equipment across the lab. Choose a good spot for each piece, and when it's exactly where you want it to be, press RETURN.
- The right arm will release its grip; it is now free to get another piece of equipment.
- To get rid of unwanted equipment, just reverse the process: Move the right arm over to the equipment. The gripper must touch the piece in exactly the same place as before. Press RETURN to grip it. Then carry the equipment back to the platform. Press RETURN again to release the arm, and press the

right-arrow cursor key to move it all the way to the right. Now simply press the down-arrow cursor key (or D) and the equipment will return to the basement storage area.

You can only move equipment, however, if it has not been used. Once you put something in it or activate it, it cannot be moved. To get rid of it then, you will have to clear the lab (press C) and start all over. So when you set up your lab, plan ahead!

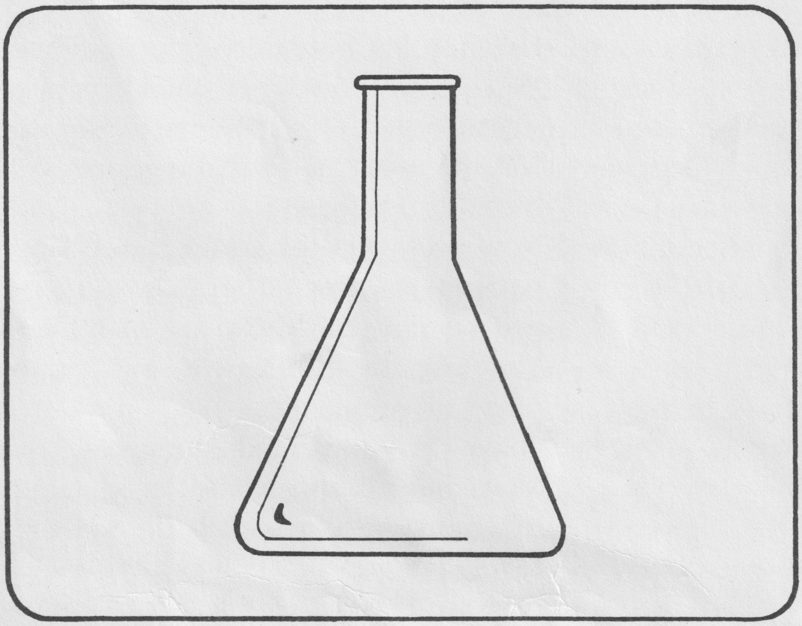
Fully Equipped

With the five basic pieces of equipment, you can perform all fifty experiments. It's only a matter of how you use them. So here are some tips.

Flask

The *flask* is the only container for gases, because it can be corked. Store a gas here, and then use the condenser, collector, or dryer to complete your experiment. Of course a flask will hold solids and liquids, if you like. But be sure to put solids or liquids into the flask *before* you cork it. You cannot drop or pour them into a sealed flask, and once a flask has been corked it can't be uncorked.

Figure 12
The flask



Beaker

The *beaker* is great for holding solids or liquids. You can boil them, mix them, or just hold them to use later. You can't store gases in it, though, because you can't seal the top.

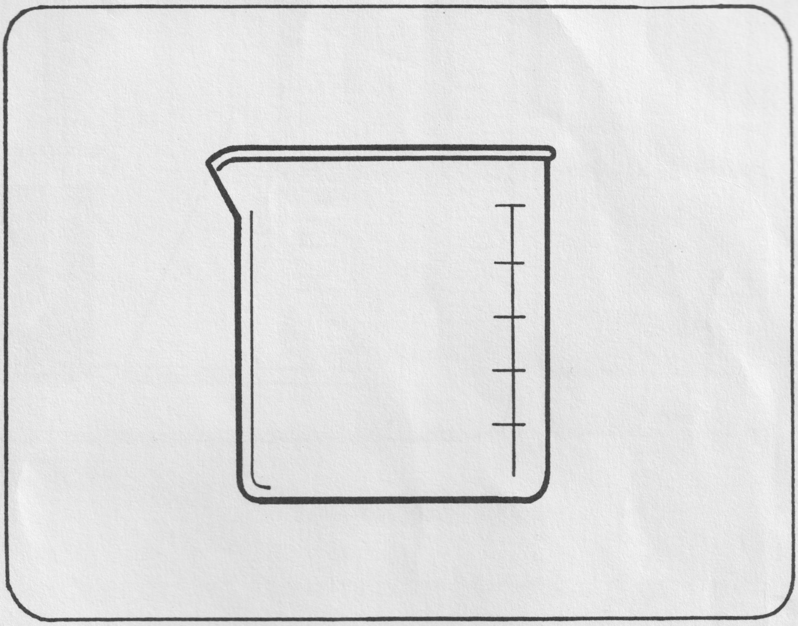


Figure 13
The beaker

Collector

The *collector* captures and isolates gases (see Figure 14, p.26). For instance, if you mix a gas and a liquid in one flask, and then want to extract only the gas, use the collector. Place the corked flask beside the collector, and the gas alone will flow into it. The liquid will remain in the flask.

Condenser

The *condenser* cools gases and transforms them into a liquid state (see Figure 15, p.26). To move a gas into the condenser, first put gas into a flask and cork it; then position the condenser to the right of the flask. The gas will flow into the condenser, cool, and liquify.

Dryer

The *dryer* does double duty: It removes steam from gases, and then allows you to use that gas in its pure state (see Figure 16, page 27).

Figure 14
The collector with a flask

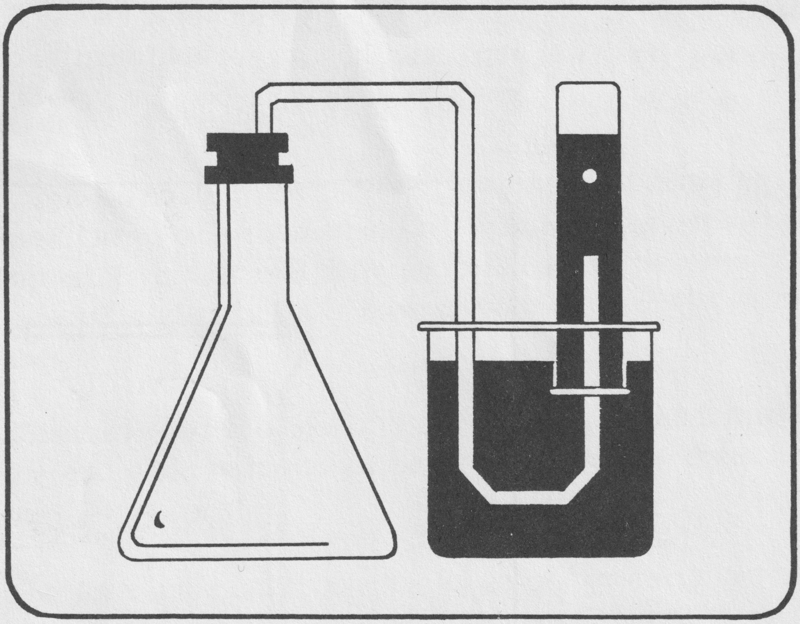


Figure 15
The condenser with a flask

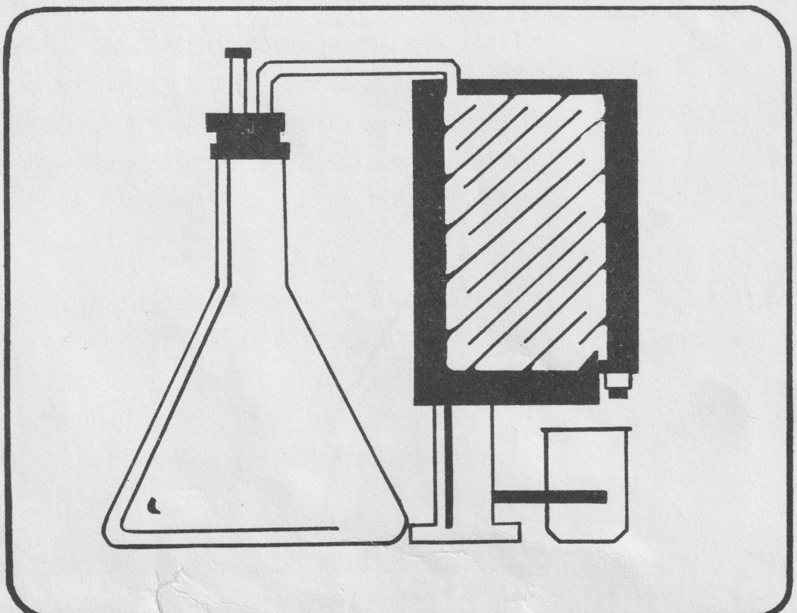
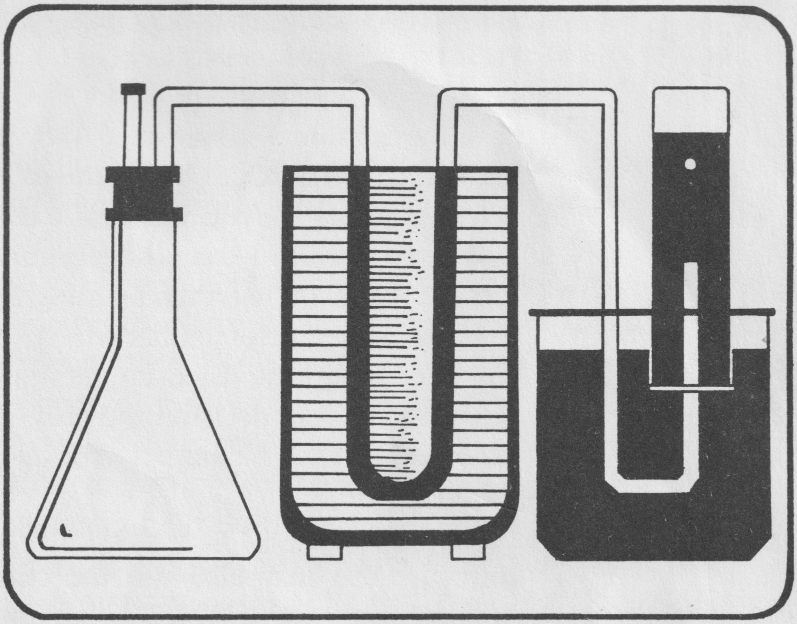


Figure 16
The dryer with the collector and a flask



The dryer can act as a connector between any gas-holding flask and the condenser or collector. Place it there, and the gas that passes through it will be dried and purified.

Getting Chemicals

Using the left robot arm with its correct hand, you can get any solid, liquid, or gas from the dispensers, or add them to your mixture.

Solids

To get a solid, follow these steps:

- Press S to see a list of the solid raw materials available for the experiment. Decide which you want and press any key to continue.
- Now get a flask or beaker from the equipment basement and place it in the lab.
- Make sure the left arm is active on the monitor. (If it isn't, press O.) Press the space bar until you see the scoop hand

appear on the left arm. It is now ready to receive a solid.

- Press the up-arrow cursor key (or U) to move the arm to the very top of the lab.
- Press the right arrow cursor key to move the arm across the lab until the scoop is exactly below the solids dispenser. When it is in the right spot, you will hear a ticking sound. This is a signal to you that you can now get a solid from the dispenser.
- Press RETURN. You will then be asked to name the solid you want. (If you can't remember which solids you wanted and you need to see the list again, hit the RETURN key and then press S. Make your decision,and press any key to remove the list of solids. Then hit RETURN to bring back the request for a solid.)
- Enter the name of the needed solid. Be sure to spell it correctly. You may also use the chemical formula. (For example, you may type **NaCl** or **sodium chloride.**)
- Now press RETURN, and the solid will drop into the scoop!
- Next use the arrow keys to position the scoop over the center of your beaker or flask, and press RETURN again.
- Perfect shot! The solid will fall into the container.

Liquids

It is the left arm's spigot that both stores and dispenses liquids. To get a liquid, do this:

- Press L to see a list of liquids available for the experiment. Decide which you want and press any key to continue.
- Make sure the left arm is active.
- Press the space bar until you see the spigot hand.
- Use the arrow keys to place the spigot over a container—a beaker or flask—before dispensing the liquid.
- Press RETURN. You will be asked to name the liquid you want. (If you need to see the list again, hit the RETURN key, then press L. To continue, press any key and then RETURN again.)
- Enter the name of the liquid or its chemical formula. Then press RETURN. (Make sure to spell correctly the name of the liquid or its chemical formula.)
- Watch it pour into the container!

Gases

To get a gas, try this:

- Press G to see which dispenser—A, B, or C—stores the gas you need.
- Get a flask ready and position it below valve 2 or 4.
- Activate the left arm, and press the space bar until you see the cork appear.
- Move the arm until it is all the way at the top of the lab just below valve 2 or 4 and directly above the flask.
- Press RETURN. The top of the cork will attach itself to the bottom of the valve.
- Press the down-arrow cursor key (or D) to move the cork down to the flask. As you move down, notice that a thin tube connects the cork to the gas dispenser above. Through this tube the gas will be able to flow.
- Press RETURN again, and the flask will be corked and connected to the gas valves above. (This disconnects the left arm from the cork. It can now be withdrawn, and used with another piece of equipment.)

Now the correct valves must be opened for the gas to flow. But which valve do you choose? To get any gas to flow from a dispenser tank to your flask, you must open two valves. First open the valve directly above the flask (either valve 2 or valve 4). Then open the tank valve corresponding to the gas you need: valve 1 for tank A, valve 3 for tank B, valve 5 for tank C.

- Press V to find out which valves are open and which are closed. Instructions also appear.
- Press O to open a valve. You will be asked, "Open which valve?" Type in the number of your choice. Press O to open a second valve. Type in the number of your second choice.
- Once you have opened the correct pair of valves, press Q to start the gas flowing into the flask. You should hear a ticking sound. (If you don't hear it, that means you chose the wrong valves and no gas is flowing. In that case, press V in order to close the incorrect valves and open the correct ones.)

- To stop the gas from flowing, press V. Then press Q to quit the flow of gas. You may then close the appropriate valves.

If you follow the directions on the screen, you won't go wrong.

Special Notes about Gases

If you plan to use gas in your experiment, it is wise to bring up a flask from the basement as soon as you enter the main lab, and place it under valve 2 or 4, where it will be ready to receive gas. Remember, once a piece of equipment is filled, it can't be moved.

Also, always *add gas last* to any mixture, because to add gas, you have to cork your flask. And once a flask is corked or sealed, it can't be uncorked. Solids or liquids cannot be added to a corked flask—only gas.

Bunsen Burners

When you're in the middle of an experiment, the heat's on you to find the right solution. And heat can sometimes be the key to getting the right chemical reaction! So it's handy to have a *Bunsen burner* to help you turn the heat on any chemical combination. There are three burners available. They are stationed at the bottom of the lab (not in the basement). Here's how they work:

- Type B to *activate* the burners. Instructions will appear.
- First, you must raise the burner you want to light. Press R to raise a burner. You'll be asked which burner you want raised.
- Enter the number of the burner you want to light: 1 (left), 2 (middle), or 3 (right). (You can light more than one.) It will appear at the bottom of the screen. It's not lit yet, just warming up for action!
- Now press E to light the burner. The flame is struck!
- When you're done heating, press B again.
- To lower the burner, press L, and enter the number of the burner you want to remove.
- Press E to exit, and you're ready to roll again!

CHEMISTRY IS EVERYWHERE

Now that you have become such a chemical whiz, here are a few things you will want to know. Keep them in mind as you experiment with Chem Lab, and they will stretch and build your mental muscles.

It's Elementary

Everything that's anything is a matter of chemistry.

That may sound odd, but think: As you now know, everything in the world is made of matter, and matter is made of chemicals! But being the brain that you are, your sharp mind doesn't stop there. So you ask the question: What are chemicals made of?

The answer is elementary, of course: *Elements* make up all the chemicals we know. In fact, there are about one hundred elements that combine and react to make the millions of substances we find on earth.

Some elements are as common as the aluminum in a soda can; some are as precious as gold or silver. Sometimes elements are right before your eyes, and you've never known it: as when you're at the beach at night and the waves seem to glow in the dark. That's phosphorus at work! Others are helping you right now—like the silicon in the chips in your computer!

You can look at what chemicals are made of by looking at their formulas. Every chemical element and compound has a name and a chemical formula. You will find the names and formulas for all of the chemicals in Chem Lab in the back of this manual, in the section called "Chemical Formulas." The formula describes the elements that make up the chemical compound and tells the chemist what elements it contains. Chemical formulas can be very short: S is the formula for sulfur, an element. Or, they can be very long: $Ca(CH_3COO)_2$ is the formula for calcium acetate.

In each case, the formula is like a code that lists all of the elements that combine to form the compound. For example, water is made of hydrogen and oxygen. The chemical formula for water is H_2O. The H stands for hydrogen and the O stands for oxygen. The 2 following the H means that there are two hydrogen atoms for each oxygen atom in every molecule of water. Therefore, water is made of hydrogen and oxygen, and that's all.

Every chemical has a formula. Sulfuric acid is made of hydrogen, oxygen, and sulfur: H_2SO_4. It has two hydrogens (H_2), one sulfur (S) and four oxygens (O_4) in each molecule. You can decipher every chemical formula if you know this simple coding system. That is important because it can help you decide which things to combine when you are in the Main Lab.

If your goal is to make water (H_2O), you must combine chemicals that have hydrogen and oxygen in their formulas in order to get the right result. The raw materials you combine may have other elements in their formulas as well, but one of your starting materials must contain hydrogen and the other must contain oxygen.

When chemicals combine and a chemical reaction occurs, the elements rearrange themselves to form new chemicals. You always finish with the same elements that you started with, but they will be arranged in different combinations. This rearranging of the elements is the chemical reaction. You never get new elements from a chemical reaction, only new arrangements of the elements you started with. Here is an example of how a

chemical reaction rearranges elements to form three new substances from two old ones. This may sound like magic, but it's just chemistry.

If you combine sulfur (S) and nitric acid (HNO_3), the elements rearrange themselves to form sulfuric acid (H_2SO_4), water (H_2O), and nitrogen dioxide (NO_2).

Notice that you have all of the same elements that you started with (sulfur, nitrogen, oxygen, and hydrogen), but they are now arranged in different combinations. You started with two chemicals (an element and a compound) and wound up with three new compounds.

If your goal had been to produce sulfuric acid (H_2SO_4), this would have been a good choice of chemicals to combine in the lab because all of the elements in H_2SO_4 were found in these two chemicals. Sulfur (S) is a good choice since it is one of the components of H_2SO_4. Nitric acid has both oxygen (O) and hydrogen (H), so it works in combination with sulfur to give sulfuric acid. But what about the extra nitrogen (N) in nitric acid? You don't need it for sulfuric acid. Should you try this combination anyway? The answer is yes. There may be extra elements in one or both of the chemicals that you combine. The important thing is that *all* of the elements you need must be present in the two chemicals you mix together.

In this case, two things happened besides making H_2SO_4. The nitrogen from the nitric acid combined with oxygen to form a new substance called nitrogen dioxide (NO_2). Also, some of the hydrogen and oxygen combined to form water (H_2O). The important thing to remember is that you should look at the formula for the target substance on the Goal Screen. Then look at the list of raw materials. Look for raw materials that have some of the same elements in their formulas as the target substance. These are good candidates for getting the target combination.

What's the Right Combination?

Compounds occur when elements chemically combine. A *chemical reaction* takes place between the elements, and together they form a new substance, a compound.

A compound can have properties very different from the elements it contains. Take sodium and chlorine, for instance. Separately, they can be dangerous and deadly. But they combine to make a tasty treat found in kitchens around the globe: salt.

By looking at how things are made, and how they react when mixed with other things, chemists can create great new substances. The vinyl of your favorite record album, the pill that stops your runny nose, even that crazy color of nail polish—chemists invented them all from nature's elements.

What a Reaction!

If you don't know now, you'll soon find out: When chemicals combine, they can produce all kinds of reactions, from a fizzle to fireworks!

There are chemical reactions happening all around you, even when you're not in the lab. When you wash the dishes, light a match, or bake a pie, chemical reactions help you get the right results. The rust on your bike and the *pop!* when you open a can of soda are chemical reactions, too.

The way chemicals react depends on many factors: the amounts you mix, the conditions under which you mix them, and the state of the chemicals themselves.

The State of the Matter

As you have seen, elements and compounds appear in three different forms—solid, liquid, and gas. These are the three states of matter. Any substance can change from one state to another, depending on its temperature, pressure, and density. Watch for these changes as you experiment with Chem Lab.

Solids are very dense. Their atoms and molecules are closely packed in a tight pattern. This is why solids have a definite shape and size.

Liquids are less dense, and the particles of which they consist form neither a pattern nor a shape of their own. A liquid will take on the shape of the container into which you pour it.

Gases are the least dense of all. Their molecules race around

very quickly, without any pattern. Gas, like liquid, takes many shapes: It fills the space of any container in which you store it.

Making Your Move

Chem Lab allows you to manipulate matter in all three states, and create hundreds of chemical reactions. Sometimes you will change a chemical from one state to another.

So go to it! The lab awaits you. Try any combination of chemicals you want. The right answer isn't always the most exciting one. Sometimes the wrong combination of elements will blow your mind—not to mention your lab—to smithereens.

DO IT YOURSELF: "DRINK ME," A PRACTICE EXPERIMENT

You've got all the facts. Now it's time for action! First try this little experiment to give you a taste of what's ahead.

To try a sip—or a gulp—of what's in store, choose "DRINK ME" from the "EXPERIMENTS" Menu. The drink's on us, this time, and here's what you'll need to do to mix it.

Study Your Experiment

Carefully read the Goal Screen. (You can refer also to p.12).

Your *raw materials* are powdered baseball, bubblegum, supernova juice, soda pop, and Alaskan gas. How about these chemicals? You certainly have your choice of solids, liquids, and gases—but which ones will mix to make your target, the Magic Elixir? That's your first mystery! When you're ready to solve it, press RETURN to move to the main lab.

Equip Yourself

You'll want to fool around with all the raw materials available to you, so we suggest you get a flask. (Remember—only a flask can capture and hold gases.)

- Use the right robot arm to get the flask and place it where you want it, anywhere in the lab. Try putting it beneath valve 2.

What a Mix-up!

There are so many raw materials ready to stir—why not make a solid choice first?

- The left robot arm will get a solid for you. Make sure the scoop hand is out. Move it under the solids dispenser, and up to the top of the lab. When you hear the clicking sound, you've got it in the right spot. Press RETURN.
- Type **POWDERED BASEBALL** and press RETURN. Plop! It drops into the scoop—and now it's up to you to transport it to the flask and drop it in.

Ready to Get Wet?

- Press the space bar until you see the spigot on the left arm. Position it over the center of the flask—it should already be there—and press RETURN.
- Type **SUPERNOVA JUICE** and press RETURN. Watch it pour!

Watch Your Lab Monitor

Look! You've caused a chemical reaction, and it says so right on the screen, as the word "MESSAGE" appears on the monitor.

- Press M to get more details on the commotion you've caused! Then press any key to get back to your experiment.

Every time you make a chemical reaction, whether it creates your target substance or not, you will see the words "MESSAGE" or "REACTION MESSAGE" on your lab monitor. Pressing M will get you the inside story and let you find out the gory details.

That's stage one. (This is a two-stage experiment.) Now you have to use the chemical compound you've just made to perform stage two. Your compound is not only bubbling in the flask, though. Press G to check out what's in gas dispenser B. You will find a new gas there—the vapor you created!

A Real Gas

Now it's time to add some gas to your concoction. Why not try some from the far north—Alaskan gas, to be exact.

- Press the space bar until you see the cork.
- Move the cork directly over the flask, and then up to the valve. Now press RETURN.
- Use the down-arrow cursor key (or D) to connect the cork with the flask, and press RETURN again. You're hooked!
- Press G to see which tank holds Alaskan gas. It's tank A. That means you need to open valve 1 (for tank A) and valve 2 (for the flask).You may also add some mosaic vapor from gas tank B if you like.
- Press V to see what valves are open.
- If the valves are closed, press O and then the correct valve numbers to get the valves you want to open. (Press O, then 1. Press O, then 2. You may also press O, then 3.)
- Now press Q to start the gas flowing. Listen to it bubble!

Hot Stuff

No reaction? How about adding a little heat to the matter.

- Press B and raise the Bunsen burner beneath your flask—it should be burner 1. Then press E to light the fire and get it going.

Bubble, bubble, toil and—*TROUBLE!*

- Press M to get your message.

Now you're ready for some other experiments. There are hundreds of different drinks to mix here, and dozens of different ways to stir up trouble. When you're ready for your next challenge, press ESC. You'll return to the "EXPERIMENTS" screen, and you can choose a new one.

Feel free to fool around and see what you can create. Chem Lab is picking up the tab—all in the name of science! And best of all, you don't have to clean up!

CHEM LAB LOG

This chapter lists and describes all fifty experiments including the practice experiment, along with the raw materials and the goal substance for each. Every element and compound is identified as a solid (*s*), liquid (*l*), or gas (*g*). This information also appears on the Goal Screen for each experiment you choose. You can check it out here while you conduct an experiment to keep your goal fresh in your mind.

Remember, each experiment is a mystery. Your job is to solve the mystery. After all, why do you think the result is called a *solution*?

Chem Lab Experiments

1. DRINK ME (Practice) Level 1

Take a pinch of powdered baseball, add a spritz of supernova juice . . . give it a burst of fresh Alaskan gas, and cork up! Now heat this magical mixture—and you've made the fabulous Chem Lab cocktail. But watch out—one sip goes a long way!

Raw Materials: (*s*) powdered baseball, (*s*) bubblegum, (*l*) supernova juice, (*l*) soda pop, (*g*) Alaskan gas
Target: magic elixir

2. GET WET — Level 1

This experiment helps you discover what the condenser can do. Use the right robot arm to bring it into the lab, and put it anywhere you like. Now it's up to you: Mess with it and see what happens!

Raw Materials: (*s*) gold, (*s*) carbon, (*s*) platinum, (*g*) oxygen, (*g*) argon, (*g*) krypton
Target: cooled liquid gas

3. OVER THE RAINBOW — Level 1

Chemicals are mysterious and magical: They hold many secrets that only a chemist can discover. In fact, with them—and within them—you may see the most beautiful vision that nature has to offer: a rainbow of color. Can you deduce how to produce a color from the chemicals you have at hand?

Raw Materials: (*s*) potassium nitrate, (*s*) copper nitrate, (*s*) calcium nitrate, (*g*) oxygen, (*g*) argon
Target: a world of color.

4. LOAD THE DRYER — Level 1

In many experiments, chemists use the dryer with the collector or the condenser. Now it's your turn: How many ways can you use them together? And what happens when you do?

Raw Materials: (*s*) aluminum, (*s*) manganese, (*s*) zinc, (*s*) chromium, (*l*) hydrochloric acid
Target: to remove H_2O from hydrogen gas (H_2)

5. PINCH-HITTING — Level 1

Seasoning your favorite stew, you realize that you've added enough herbs, squeezed enough lemon, and stirred in enough stock—but it still doesn't taste as delicious as last time. Aha! You've got it. Can you create the needed ingredient to make your dinner a mouthwatering treat?

Raw Materials: (*s*) sodium hydroxide, (*l*) hydrochloric acid, (*l*) water, (*g*) hydrogen, (*g*) nitrogen
Target: (*s*) sodium chloride (NaCl)

6. WHAT A GAS! Level 1

Chemists use the collector for a variety of experiments, but it does the same thing every time—collects and stores gas. Try it out and see what it will do for you.

Raw Materials: (*s*) calcium, (*s*) magnesium, (*s*) barium, (*l*) water, (*g*) hydrogen, (*g*) oxygen
Target: a collected gas

7. CHALK IT UP Level 2

Your favorite teacher is in the middle of a lesson, and just as he's drawing a map of Asia Minor, he runs out of chalk! No problem, you call as you make a quick dash to your lab. But can you create the chalk he needs before school is out?

Raw Materials: (*s*) calcium hydroxide, (*l*) carbonic acid, (*g*) nitrogen, (*g*) hydrogen
Target: (*s*) calcium carbonate ($CaCO_3$)

8. DRINK UP! Level 1

Phew! That noonday sun is hot—and when you enter your lab, all you can think of is a cool, tall glass of water. All the makings of earth's most thirst-quenching beverage are right before you. Can you mix yourself a drink?

Raw Materials: (*s*) silver, (*s*) gold, (*s*) sodium hydroxide, (*l*) sulfuric acid, (*l*) ~~mercury~~ mercury (S)
Target: (*l*) water (H_2O)

9. RATS! Level 2

They started in the sewers, and now they've taken to the streets! Thousands of rats roam the city—and only you know the secret formula that will exterminate the horde. Can you concoct the rat poison in time?

Raw Materials: (*s*) carbon, (*s*) lead, (*s*) sulfur, (*l*) nitric acid, (*l*) sulfuric acid, (*g*) carbon dioxide
Target: (*l*) carbon disulfide (CS_2)

10. CAUGHT RED-HANDED Level 2

You've been called in to solve the crime of the century. You take out your whodunit kit to case the joint, but a key item is missing—the fingerprint dust. Can you stir up some powder in a hurry, and get to the bottom of this case?

Raw Materials: (*s*) silver nitrate, (*s*) sodium chloride, (*s*) potassium, (*s*) gold, (*g*) nitrogen, (*g*) krypton
Target: (*s*) silver chloride ($AgCl$)

11. CRYSTAL CLEAR Level 2

The winds and rain of early spring are over and the hot weather has come to stay. It's time to fill the swimming pool. But look at the dirt and slime that has been there all winter. What would be a good strong mix to clear out this mess and make the pool crystal clear?

Raw Materials: (*s*) copper, (*s*) zinc, (*l*) water, (*g*) oxygen, (*g*) nitrogen, (*g*) chlorine
Target: hydrochloric acid (HCl)

12. THE COVER-UP Level 3

The graduation party was great, but now that it's over, there are piles of food left. You'd love to save these yummies for a midnight raid, but you've run out of containers. Can you whip up something to wrap up this problem?

Raw Materials: (*s*) stannic oxide, (*s*) carbon, (*s*) gold, (*l*) water, (*g*) nitrogen, (*g*) oxygen, (*g*) krypton
Target: (*s*) tin (Sn)

13. ALL THAT GLITTERS Level 2

In the attic you found an old wooden box that belonged to your great-aunt. Hoping for some glistening treasure inside, you pried it open, only to find a dull, black bowl. But wait, it was a find! Pure silver, only badly tarnished. What made it turn black?

Raw Materials: (*s*) silver, (*s*) sulfur, (*s*) sodium chloride, (*l*) water, (*l*) hydrochloric acid, (*g*) hydrogen
Target: (*g*) hydrogen sulfide (H_2S)

14. THE JOKE'S ON YOU! Level 2

You're a bright young comedian about to make your debut. Here's one way to have the crowd rolling in the aisles—make laughing gas!

Raw Materials: (*s*) tin, (*s*) sodium nitrate, (*s*) ammonium sulfate, (*l*) hydrochloric acid, (*g*) nitrogen, (*g*) oxygen
Target: (*g*) nitrous oxide (N_2O)

15. FEED FOR THOUGHT Level 1

An explosion rips through the Feedrite Fertilizer Company, and, as its chief chemist, only you can determine the cause. What's your theory on the big boom?

Raw Materials: (*s*) sulfur, (*s*) sodium chloride, (*s*) iron oxide, (*l*) nitric acid, (*l*) ammonium hydroxide, (*g*) fluorine
Target: (*s*) ammonium nitrate (NH_4NO_3)

16. SEEING THE LIGHT Level 1

You and your crew have laid miles of railbed, but now you are faced with your greatest obstacle yet: a sheer face of rock. The next town is just over the ridge, but the only way to reach it is to blast a tunnel right through the rock. Can you do it?

Raw Materials: (*l*) sulfuric acid, (*l*) glycerin, (*l*) nitric acid, (*l*) water, (*g*) chlorine, (*g*) nitrogen, (*g*) carbon dioxide
Target: (*l*) nitroglycerin ($CH_2NO_3CHNO_3CH_2NO_3$)

17. WHAT A PANE Level 3

You know it's been cloudy lately, but today the view from your window is absolutely bleak. But then you realize that it's the glass that's dingy, not the day! Can you concoct a potion to wipe the grime away?

Raw Materials: (*s*) ammonium fluoborate, (*s*) boron trioxide, (*s*) sodium hydroxide, (*l*) water, (*l*) sulfuric acid, (*l*) ammonia
Target: (*l*) ammonium hydroxide (NH_4OH)

18. PURE AND SIMPLE — Level 2

Hurricane Norma wreaked havoc all over town. Trees and lines are down, but worst of all, the sewers are backed up into the water supply. Can you clean up this mess and make the water drinkable again?

Raw Materials: (*s*) manganese dioxide, (*l*) water, (*l*) hydrochloric acid, (*g*) hydrogen, (*g*) oxygen, (*g*) carbon dioxide
Target: (*g*) chlorine (Cl_2)

19. BURNED OUT — Level 3

The campfire is still hissing and crackling, but it's time to turn in for the night. But before you retire, you would like to extinguish the fire. What's the best way to put the fire out?

Raw Materials: (*s*) sodium, (*s*) calcium, (*s*) sodium bicarbonate, (*l*) sulfuric acid, (*l*) water, (*g*) carbon monoxide
Target: (*g*) carbon dioxide (CO_2)

20. LET THE SUN SHINE — Level 2

You can't remember the last really clear, sunny day; and as head meteorologist, it concerns you. Production at the plant nearby is at an all-time high. Something is blocking the sun. What mess in the air is causing the hazy skies? Can you find it?

Raw Materials: (*s*) carbon, (*s*) sulfur, (*s*) calcium, (*g*) oxygen, (*g*) hydrogen
Target: (*g*) carbon dioxide (CO_2)

21. KNOCK KNOCK — Level 2

Revving up for the first leg of the big race, you hear the unmistakable, unsettling knock of gasoline in your engine. There is just enough time to make a prerace pit stop; but how will you get the knock out?

Raw Materials: (*s*) magnesium, (*s*) calcium, (*s*) calcium bromide, (*l*) water, (*g*) oxygen, (*g*) chlorine
Target: (*s*) calcium chloride ($CaCl_2$) and (*l*) bromine (Br_2)

22. BUG OFF! Level 3

You have just returned to your cabin in the woods—but instead of finding it clean and tidy as you left it, you see ants everywhere you look. You'd better act fast to get rid of these pests, before they make themselves at home!

Raw Materials: (*s*) phosphorus, (*l*) water, (*l*) nitric acid, (*l*) bromine, (*g*) nitrogen
Target: (*l*) hydrobromic acid (HBr)

23. I DO, I DO Level 3

You popped the big question, and your lady said yes. Now you'd like to give her a great-looking diamond, but it's a little beyond your budget. Here's a better idea: Make it yourself!

Raw Materials: (*s*) sodium, (*s*) calcium, (*s*) carbon, (*l*) water, (*g*) hydrogen, (*g*) oxygen
Target: a synthetic diamond

24. THE FIZZ BIZ Level 2

You are the president of a soft-drink company, and business has gone flat. Suddenly, it comes to you: You will add 10 percent more fizz to your soda, and add some new life to your sales!

Raw Materials: (*s*) magnesium, (*s*) carbon, (*l*) water, (*l*) hydrochloric acid, (*g*) hydrogen, (*g*) oxygen
Target: (*g*) carbon dioxide (CO_2)

25. WHAT'S THE SCOOP? Level 3

It is 102 degrees in the shade and the heat's on you—because inside your ice-cream van, your precious cargo is melting! The refrigeration fluid has leaked from the cooler coils. Can you make more of this chemical?

Raw Materials: (*s*) sodium, (*s*) carbon, (*l*) water, (*l*) sulfuric acid, (*g*) fluorine, (*g*) oxygen
Target: (*g*) carbon tetrafluoride (CF_4)

26. GO THE EXTRA MILE — Level 3

You have a long journey ahead of you. Your old jalopy only gets fifteen miles to the gallon. You'd rather not have to stop so often at service stations to gas up, and you want to be prepared if there's no station in sight. No problem for you. Just go to your lab and mix up some extra fuel to store in your trunk!

Raw Materials: (*s*) carbon, (*s*) platinum, (*l*) water, (*g*) carbon monoxide, (*g*) nitrogen, (*g*) hydrogen
Target: (*l*) methane (CH_4)

27. UP IN SMOKE — Level 3

You and your crew are camped out on a hillside, and your foreman and his team are camping on the next ridge. It's a beautiful, clear night, but there's one problem: Your CB radio is out. How will you communicate with your foreman and let him know your crew is all set for the night? That's easy: Send smoke rings to say you're A-OK!

Raw Materials: (*s*) phosphorus, (*s*) calcium, (*s*) sodium hydroxide, (*l*) water, (*l*) nitric acid, (*g*) oxygen
Target: (*s*) calcium phosphide (Ca_3P_2)

28. CRACKERJACK! — Level 2

You've pressed the button hidden in the bookcase, and the secret panel slides back to reveal the well-sealed safe. The secret plans are locked inside it. If only you knew the right combination! But wait—you do! Combine the right chemicals, and you hold the key to burning right through the door.

Raw Materials: (*s*) gold, (*s*) calcium, (*s*) sodium, (*l*) hydrochloric acid, (*l*) nitric acid, (*l*) water
Target: (*l*) aqua regia (one part HNO_3 to three parts HCL)

29. STOP SMOKING — Level 3

As the foreman at the Kleenair factory, you find that production is at an all-time high—but so is the black carbon and sulfur dioxide your stacks are spewing. You know that a certain

chemical compound will clear your stacks of this smoky pollution. Can you figure out how to clean up the act?

Raw Materials: (*s*) carbon, (*l*) water, (*l*) ammonia, (*g*) sulfur dioxide, (*g*) nitrogen
Target: nonpollutants

30. CHIP TRICK — Level 3

Your computer is acting a little flaky, and you inspect its CPU. You see that a chip is cracked. Holy high-tech! What can you do? It's simple: Make a brand-new chip to replace it!

Raw Materials: (*s*) calcium oxide, (*s*) silicon dioxide, (*s*) carbon, (*l*) water, (*g*) nitrogen, (*g*) oxygen
Target: (*s*) silicon (Si)

31. THE CLUBHOUSE — Level 2

The gang has made you the master builder of the new clubhouse. Because the last one collapsed during a rainstorm, your reconstruction plans call for waterproofing. But how can you make the clubhouse leakproof?

Raw Materials: (*s*) silicon dioxide, (*s*) sodium carbonate, (*s*) magnesium, (*l*) hydrochloric acid, (*g*) nitrogen, (*g*) oxygen
Target: (*s*) sodium silicate ($Na_2O{\cdot}2SiO_2$)

32. WHAT A COUPE! — Level 1

That shiny, new little blue convertible is all yours—and it's a beauty. You have washed, waxed, and polished it all day—but there is one more act of tender loving care only you can do. Can you mix up a potion to make your new car rustproof?

Raw Materials: (*s*) calcium phosphate, (*s*) potassium, (*s*) barium, (*l*) sulfuric acid, (*g*) argon, (*g*) krypton, (*g*) nitrogen
Target: (*l*) phosphoric acid (H_3PO_4)

33. MYSTERY MEAT Level 1

Lunchtime is over, and it's on to sixth period. But suddenly, a queasy feeling overtakes you. Could it be that mystery meat you ate in the cafeteria? Before you go to class, can you concoct a remedy to soothe that sinking feeling?

Raw Materials: (*s*) magnesium, (*s*) calcium, (*s*) lead, (*l*) water, (*g*) hydrogen, (*g*) nitrogen
Target: (*s*) magnesium hydroxide ($Mg(OH)_2$)

34. A STEELY DEAL Level 2

You finally got that flashy new 18-speed bike. But your old rusty lock won't do to keep it safe. Can you find the metal the lock maker forgot to add to his steel to help keep your lock free of rust?

Raw Materials: (*s*) iron oxide, (*s*) copper oxide, (*s*) nickel oxide, (*s*) zinc oxide, (*l*) water, (*g*) hydrogen
Target: (*s*) nickel (Ni)

35. SUNRISE, SUNSET Level 3

Standing on the pier, you can watch the sun sink below the horizon. The sky is a kaleidoscope of color this evening: yellows, reds, and purples the likes of which you've never seen. The colors, in fact, are a little unnatural—can you figure out just what under the sun is causing them to glow?

Raw Materials: (*s*) lead oxide, (*s*) carbon, (*l*) nitric acid, (*l*) hydrochloric acid, (*g*) hydrogen, (*g*) nitrogen
Target: (*s*) lead (Pb) and (*g*) carbon monoxide (CO)

36. FOR ART'S SAKE Level 3

Scraps of steel and strips of metal (also known as your masterpiece) lie before you, ready to be joined. That new gallery needs your new sculpture as soon as possible—but, torch in hand, you realize that your flame is out. Can you mix up the fuel to finish your work of art?

Raw Materials: (*s*) calcium carbide, (*s*) sodium chloride, (*l*) carbon disulfide, (*l*) water, (*l*) hydrochloric acid, (*g*) nitrogen
Target: (*g*) acetylene ($HC\equiv CH$)

37. MMM, MMM, GOOD! Level 2

Some new friends are coming over for dinner tonight, and you would love to wow them with one of your amazing salads. You gather your fresh veggies from the garden, uncork your best olive oil, but then—holy tomato!—you discover that you're missing a key ingredient: vinegar! No problem for you: You'll mix up a homemade batch!

Raw Materials: (*s*)calcium acetate, (*l*) water, (*l*) sulfuric acid, (*g*) nitrogen, (*g*) oxygen
Target: (*l*) acetic acid (CH_3COOH)

38. IN SHORT SUPPLY Level 3

Your lab is stocked with almost all the chemicals you could ever need, with one important exception: a reactive agent. You need this ingredient to get many of your chemical reactions moving. You're running so you'd better mix some more right away!

Raw Materials: (*s*) magnesium, (*l*) water, (*l*) hydrochloric acid, (*l*) bromine, (*g*) nitrogen, (*g*) hydrogen
Target: (*l*) hydrogen bromide (HBr)

39. BAR EXAM Level 3

You would like to build a jungle gym for your spiffy new rec room, but you're at a loss for one important element. Where are you going to get the metal to build it? Before you can jump, climb, or swing, can you create a source of metal to build your bars?

Raw Materials: (*s*) iron oxide, (*s*) silver, (*g*) carbon monoxide, (*g*) nitrogen, (*g*) hydrogen
Target: (*s*) iron (Fe)

40. TOO HOT TO HANDLE Level 3

Bubble, bubble, toil and—wow! You are quickly becoming a first-rate chemist. Your experiments are now more complex—and the chemicals you use, more and more dangerous. What will happen to you, and your lab assistants, if you're not careful?

Raw Materials: (*s*) phosphorus, (*s*) potassium, (*s*) sodium, (*l*) water, (*l*) ether, (*l*) carbon disulfide, (*g*) oxygen
Target: (*l*) ether peroxide [$CH_3C(OH)HO{\cdot}OH(OH)CCH_3$]

41. HARD TO SWALLOW Level 3

You've hiked halfway up the mountain trail, and as you turn a bend, a beautiful vista greets you and you rest. Wiping your brow, you take a sip from your canteen. But what happened to the water? It tastes foul! Why is it so hard to swallow?

Raw Materials: (*s*) calcium oxide, (*s*) gold, (*s*) magnesium, (*l*) water, (*l*) sulfuric acid, (*g*) nitrogen
Target: (*s*) calcium sulfate ($CaSO_4$)

42. A QUICKIE Level 3

Adding, stirring, heating, and cooling—you've been working since dawn on different experiments. Some go slow and others are speedier than a Porsche. Which reaction is the quickest?

Raw Materials: (*s*) copper, (*s*) platinum, (*l*) ammonia, (*g*) carbon monoxide, (*g*) oxygen, (*g*) hydrogen
Target: (*g*) nitric oxide (NO)

43. SMILE! Level 2

There has been a 300% increase in tooth decay since the chocolate factory opened in town. You are asked to create in your lab an anticavity agent for the toothpaste company. Can you mix one up and still enjoy the chocolate?

Raw Materials: (*s*) potassium fluoride, (*s*) magnesium, (*s*) sodium, (*s*) zinc, (*l*) hydrofluoric acid, (*l*) water
Target: (*s*) sodium fluoride (NaF)

44. SOME LIKE IT HOT — Level 2

It's chilly in your lab, and even your Bunsen burner can't offer enough heat. All you have to keep you warm are your tools, equipment, and of course your wide array of chemicals. Hot tamale! You know that some mixtures will actually produce heat. Can you stir up the mixture that will warm you the best?

Raw Materials: (s) gold, (s) carbon, (g) hydrogen, (g) oxygen, (g) chlorine
Target: (g) carbon dioxide (CO_2)

45. LIGHT UP THE SKY — Level 1

The Fourth of July is just around the corner—and your friends are counting on you for a spectacular sky show. As you make some fireworks to rocket and burst in the air, your lab is as bright as the glorious Fourth! In each experiment you perform, the reaction flashes differently. Can you create one that bursts brighter than all the rest?

Raw Materials: (s) sulfur, (s) antimony, (s) copper, (s) zinc, (g) nitrogen, (g) chlorine
Target: (l) sulfur chloride (S_2Cl_2)

46. TRAVELING LIGHT — Level 3

The metal go-cart you made placed dead last in the big race. For next week's rally, you're determined to rebuild it. Can you add something to the metal to make it sturdier yet lighter and speedy enough to beat the best?

Raw Materials: (s) magnesium oxide, (s) sodium, (s) silicon, (l) sulfuric acid, (l) water, (g) nitrogen
Target: (s) magnesium (Mg)

47. LOCK, STOCK, AND BARREL — Level 2

The big bash you've been planning for weeks will begin in an hour or two. It's time to get all the party supplies that you stored in the shed. Hold it! The shed door is locked with a great bolt,

and you've forgotten where you hid the key. An acid will eat right through this little problem—but which one will work best on the lock?

Raw Materials: (*s*) platinum, (*s*) carbon, (*l*) water, (*g*) krypton, (*g*) sulfur dioxide, (*g*) oxygen
Target: (*l*) sulfuric acid (H_2SO_4)

48. WHAT'S UP DOC? Level 1
Your first patient is ready and waiting for his X-ray examination. You need to make sure that you give him a thorough checkup. You can stir up a secret potion, give him a sip, and—presto!—his X-rays glow in the dark.

Raw Materials: (*s*) barium hydroxide, (*l*) sulfuric acid, (*l*) water, (*g*) hydrogen, (*g*) nitrogen
Target: (*s*) barium sulfate ($BaSO_4$)

49. THE PARTY'S OVER Level 2
You can't believe you ate the whole thing—a six-foot hero sandwich—and you didn't even stop to offer anyone else a bite. Well, it was great while it lasted—but now your stomach is telling you a different tale. It hurts! What can you do to settle its churning, once and for all?

Raw Materials: (*s*) calcium carbonate, (*s*) lead, (*s*) magnesium, (*s*) sodium, (*l*) hydrochloric acid, (*g*) hydrogen
Target: (*l*) water (H_2O) and (*g*) carbon dioxide (CO_2)

50. BLINDED BY THE LIGHT Level 2
You're a hotshot chemist, for sure, but you'd like to add some flash to your act. Zap! Here are all the ingredients you need to discover what it takes to light up your life.

Raw Materials: (*s*) magnesium, (*s*) aluminum, (*s*) calcium, (*s*) iron, (*g*) oxygen
Target: (*s*) magnesium oxide (MgO)

ON YOUR OWN: TERMS

Here are some words you can slip into your dinner conversation when you don't want your folks to notice that you're not eating your spinach. And here's what they mean—in case anyone asks:

acids Chemical compounds that produce hydrogen when they are placed in water, and that also often contain oxygen. Acids have a sour or sharp taste and a strong smell—but don't taste them! Strong acids burn and sting, and some can even melt metal or your tongue!

activation energy The energy needed to start a reaction. Turn up the heat!

alkali A substance that neutralizes an acid to form a salt and water. (What you put on your sneakers to keep them from melting after you spill acid on them.) *See also* **bases.**

atom The smallest building block of an element that still has the qualities of that element. Atoms are the tiniest workers in every chemical reaction. (They're small but mighty!) Each atom is made up of an equal number of protons and electrons. The protons have a positive charge and are found at the core, or nucleus, of the atom. The electrons have a negative charge and speed around the nucleus of the atom. Electrons are nearly weightless.

bases Chemical "opposites" of acids. Many bases can dissolve in water: these are called alkalis. Bases taste bitter and feel soapy. Some bases you may find at home are oven cleaner, detergent, and tablets to soothe your stomachaches.

beaker A heat-resistant, wide-mouthed glass container used to combine and store solids and liquids. Marked for measurement, it allows you to see how much of each substance you add to your mixture. Don't use a beaker to store gases, though: They will fly right out the top!

chemical reaction A change in the atomic structure of a substance that transforms it into a new substance, and sometimes blows up in the process.

collector A piece of equipment that will extract and capture a gas from a mixture. In Chem Lab, to isolate the gas from the other substances in a flask, place the flask next to the collector. The gas alone will flow into the collector and remain.

combustion Burning that gives out heat and light—in other words, a flame or an explosion.

compound A chemical combination of two or more substances: What you are trying to make in Chem Lab.

condenser A piece of equipment that cools gases and changes them into liquids. To transform any gas into a liquid, place its holding flask beside the condenser. The gas will flow into the condenser and change into a liquid.

decomposition Breaking down a complex substance into simpler ones. Splitting a compound into its elements is an example of decomposition.

distillation Collecting a gas by condensing it into a liquid, so it can be easily mixed with solids and other liquids.

dryer A piece of equipment that removes steam from any gas. Use the dryer with the collector to hold the gas in its pure state, or use it with the condenser to change the pure gas into a liquid for later use.

element A simple substance which cannot be split chemically into smaller substances. There are about one hundred elements. Everything in the world is made of elements and their combinations.

equation The way chemists write down chemical reactions, using the symbols and formulas of the chemicals involved. Example: $2H_2 + O_2 = 2H_2O$.

evaporation Converting a liquid into a gas, as in boiling. It's also how you dry off after you get out of the pool when you've forgotten your towel.

flask A heat-resistant, small-necked glass container, best for storing and combining gases with other substances. Use the cork to keep the gas in the flask—and you can heat it, condense it, dry it, or collect more gas.

products The substances formed by a chemical reaction. Watch the reaction message to see the products you've made.

salt A type of compound formed when the hydrogen in an acid is replaced by a metal. Along with acids and bases, salts are the most common kind of compound—NaCl, the salt you put on your food, is just one kind!

solution A solid that is dissolved in a liquid.

solvent A liquid in which other substances can dissolve. Acids are great solvents.

CHEMICAL FORMULAS

In this section, you will find a list of all the chemicals found in Chem Lab, and their formulas as well. When you are in the main lab and you need a solid, liquid, or gas, you can type in the name of the chemical you want; you can also type in its formula. Chemical formulas will impress your friends. After all, what chemist doesn't refer to ammonium fluoborate as NH_4BF_4?

First, there are some things you should know about the way chemical formulas are designed. Remember, there are about 100 chemical elements. (Actually there are 105 in all, to be precise.) Take a look at the chart on page 69 to see them all. This chart is called a *periodic table.*

Each element has a name and a chemical abbreviation. The abbreviation is always one or two letters long. Sometimes it is the first letter of the element's name—such as *C* for carbon or *O* for oxygen. Sometimes the abbreviation comes from the Greek or Latin name for the element—*Fe* for iron (Latin *ferrum*) or *Sn* for Tin (Latin *stannum*). (Bet you didn't know that some food comes in stannous cans, did you?)

The abbreviations are important because they are used in chemical formulas. A chemical formula simply describes the elements that make up one molecule (or particle) of a substance. Water, as you no doubt know, is H_2O. That means it is made of hydrogen (H) and oxygen (O). The *2* in H_2O tells you

that there are two hydrogen atoms for each oxygen atom in one water molecule.

So, you see, chemical formulas are really simple to understand. They are just a list of the elements that make up a chemical, with numbers that tell how many atoms of each element there are in one molecule of the chemical. The following list of chemicals with their formulas contains all the raw materials and target substances found in Chem Lab. Also, after each chemical name is a letter (*s*), (*l*), or (*g*). This tells you whether the chemical is a solid, liquid, or gas at room temperature. Whenever you want to get a chemical in the main lab, type in either the name of the chemical or its formula. Try using the formula; you might like it and have some fun.

Chemical	Formula
acetic acid (*l*)	CH_3COOH
acetylene (*g*)	$HC{\equiv}CH$
aluminum chloride (*s*)	$AlCl_3$
aluminum oxide (*s*)	Al_2O_3
ammonia (*g* or *l*)	NH_3
ammonium chloride (*s*)	NH_4Cl
ammonium fluoborate (*s*)	NH_4BF_4
ammonium hydroxide (*l*)	NH_4OH
ammonium nitrate (*s*)	NH_4NO_3
ammonium pentasulfide (*s*)	$(NH_4)_2S_5$
ammonium sulfate (*s*)	$(NH_4)_2SO_4$
antimony (*s*)	Sb
antimony trichloride (*s*)	$SbCl_3$

aqua regia (*l*)	one part HNO_3 to three parts HCl
argon (*g*)	Ar
barium (*s*)	Ba
barium hydroxide (*s*)	$Ba(OH)_2$
barium phosphate (*s*)	$BaHPO_4$
barium sulfate (*s*)	$BaSO_4$
boric acid (*s*)	H_3BO_3
boron nitride (*s*)	BN
boron trioxide (*s*)	B_2O_3
bromic acid (*l*)	$HBrO_3$
bromine (*l*)	Br_2
calcium (*s*)	Ca
calcium acetate (*s*)	$Ca(CH_3COO)_2$
calcium bromide (*s*)	$CaBr_2$
calcium carbide (*s*)	CaC_2
calcium carbonate (*s*)	$CaCO_3$
calcium chloride (*s*)	$CaCl_2$
calcium cyanamide (*s*)	$N{\equiv}CN{=}Ca$
calcium hydride (*s*)	CaH_2
calcium hydroxide (*s*)	$Ca(OH)_2$
calcium nitrate (*s*)	$Ca(NO_3)_2$
calcium nitride (*s*)	Ca_3N_2
calcium oxide (*s*)	CaO
calcium phosphate (*s*)	$CaHPO_4$

calcium phosphide (*s*)	Ca_3P_2
calcium sulfate (*s*)	$CaSO_4$
calcium sulfide (*s*)	CaS
carbon (*s*)	C
carbon dioxide (*g*)	CO_2
carbon disulfide (*l*)	CS_2
carbonic acid (*l*)	H_2CO_3
carbon monoxide (*g*)	CO
carbon tetrafloride (*g*)	CF_4
chlorine (*g*)	Cl_2
chlorine dioxide (*g*)	ClO_2
chromium (*s*)	Cr
chromium chloride (chromic chloride) (*s*)	$CrCl_3$
copper (*s*)	Cu
copper chloride (cupric chloride) (*s*)	$CuCl_2$
copper hydroxide (cupric hydroxide) (*s*)	$Cu(OH)_2$
copper nitrate (cupric nitrate) (*s*)	$Cu(NO_3)_2$
copper oxide (cuprous oxide) (*s*)	Cu_2O
cyanogen (*g*)	$N\equiv C\equiv C\equiv N$
diamonds, synthetic (carbon) (*s*)	C
dry ice (carbon dioxide) (*s*)	CO_2
ether (*l*)	$(C_2H_5)2O$
ether peroxide (*l*)	$CH_3C(OH)HO{\cdot}OH(OH)CCH_3$
fluorine (*g*)	F_2
glycerin (*l*)	$C_3H_5(OH)_3$

gold (*s*)	Au
hydrobromic acid (*l*)	HBr in H_2O
hydrochloric acid (*l*)	HCl in H_2O
hydrofluoric acid (*l*)	HF in H_2O
hydrogen (*g*)	H_2
hydrogen peroxide (*l*)	H_2O_2
hydrogen sulfide (*g*)	H_2S
iodine (*s*)	I_2
iron (*s*)	Fe
iron fluoride (ferric fluoride) (*s*)	FeF_3
iron hydroxide (ferric hydroxide) (*s*)	$Fe(OH)_3$
iron monoxide (*s*)	FeO
iron nitrate (ferric nitrate) (*s*)	$Fe(NO_3)_3$
iron oxide red (ferric oxide) (*s*)	Fe_2O_3
krypton (*g*)	Kr
lead (*s*)	Pb
lead chloride (*s*)	$PbCl_2$
lead nitrate (*s*)	$Pb(NO_3)_2$
lead oxide (*s*)	Pb_3O_4
lithium chloride (*s*)	$LiCl$
magnesium (*s*)	Mg
magnesium bromide (*s*)	$MgBr_2$
magnesium carbide (*s*)	Mg_2C_3
magnesium chloride (*s*)	$MgCl_2$
magnesium fluoride (*s*)	MgF_2

magnesium hydride (*s*)	MgH_2
magnesium hydroxide (*s*)	$Mg(OH)_2$
magnesium nitride (*s*)	Mg_3N_2
magnesium oxide (*s*)	MgO
magnesium sulfate (*s*)	$MgSO_4$
magnetite (*s*)	Fe_3O_4
manganese (*s*)	Mn
manganese chloride (*s*)	$MnCl_2$
manganese dioxide (*s*)	MnO_2
manganese oxide (*s*)	MnO
manganese sulfate (*s*)	$MnSO_4$
mercury (*l*)	Hg
methane (*l or g*)	CH_4
nickel (*s*)	Ni
nickel hydroxide (*s*)	$Ni(OH)_2$
nickel oxide (*s*)	NiO
nitric acid (*l*)	HNO_3
nitric oxide (*g*)	NO
nitrogen (*g*)	N_2
nitrogen dioxide (*g*)	NO_2
nitrogen oxyfluoride (*g*)	NO_3F
nitroglycerin (*l*)	$CH_2NO_3CHNO_3CH_2NO_3$
nitrous acid (*l*)	HNO_2
nitrous oxide (*g*)	N_2O
oxygen (*g*)	O_2

phosphine (*g*)	PH_3
phosphoric acid (*l*)	H_3PO_4
phosphorus (*s*)	P
phosphorus pentoxide (*s*)	P_2O_5
phosphorus tribromide (*l*)	PBr_3
platinum (*s*)	Pt
potassium (*s*)	K
potassium chloride (*s*)	KCl
potassium fluoride (*s*)	KF
potassium nitrate (*s*)	KNO_3
potassium peroxide (*s*)	K_2O_2
potassium phosphate (*s*)	K_2HPO_4
silicon (*s*)	Si
silicon dioxide (*s*)	SiO_2
silver (*s*)	Ag
silver chloride (*s*)	AlCl
silver nitrate (*s*)	$AgNO_3$
silver sulfide (*s*)	Ag_2S
sodium (*s*)	Na
sodium bicarbonate (*s*)	$NaHCO_3$
sodium borate (*s*)	$Na_2B_4O_7$
sodium carbide (*s*)	Na_2C_2
sodium carbonate (*s*)	Na_2CO_3
sodium chloride (*s*)	NaCl
sodium fluoride (*s*)	NaF

sodium hydroxide (*s*)	$NaOH$
sodium nitrate (*s*)	$NaNO_3$
sodium nitride (*s*)	Na_3N
sodium peroxide (*s*)	Na_2O_2
sodium silicate (*s*)	$Na_2O \cdot 2SIO_2$
sodium sulfate (*s*)	Na_2SO_4
stannic oxide (tin oxide) (*s*)	SnO_2
sulfur (*s*)	S
sulfur chloride (*l*)	S_2Cl_2
sulfur dioxide (*g*)	SO_2
sulfuric acid (*l*)	H_2SO_4
sulfur trioxide (*s*)	SO_3
tin (*s*)	Sn
tin chloride (stannic chloride) (*l*)	$SnCl_4$
tin oxide (stannous oxide) (*s*)	SnO
water (*l*)	H_2O
zinc (*s*)	Zn
zinc chloride (*s*)	$ZnCl_2$
zinc fluoride (*s*)	ZnF_2
zinc oxide (*s*)	ZnO

THE PERIODIC TABLE

The periodic table is a chart of all 105 elements; it is shaded here to show the state of each element at room temperature, whether solid, liquid, or gas. The periodic table arranges the elements in rows called "periods," ordering them by atomic number. The atomic number tells you how many protons are in one atom of that element. An atom of hydrogen, for example, has only one proton. It's the lighest of all the elements.

Most of the elements are solid at room temperature. A few are gaseous: nitrogen, oxygen, fluorine, chlorine, hydrogen, and the "noble gases." Only two familiar elements are liquid: mercury and bromine.

Most elements are metals. They have a shine or luster to them, they can be made into wires, and they can be pounded into flat sheets. They are also good conductors of electricity. The metals are at the left of the chart.

The nonmetals are grouped at the right of the chart. Many of them are gases.

The periodic table arranges the elements in vertical patterns called "groups," as well. Each vertical column contains elements with similar atomic structures.

The metals in the first group at the left, like sodium (Na), are so chemically reactive that they rarely occur in pure form in nature. They react quickly. They react violently with water. These metals are so soft that they can be cut with a knife.

The metals in the second group on the left, like calcium (Ca) and magnesium (Mg), are called earth metals; they are usually found in deposits underground.

The noble gases, like argon (Ar) at the far right of the chart, are called "noble" because they are rare and do not mix with other chemicals readily. They are odorless, colorless, and inactive.

The nonmetals in the second column from the right, like fluorine (F) and chlorine (Cl), react so quickly with almost all the other elements that often they produce a violent and even explosive reaction.

The Periodic Table

Groups → / Periods ↓	I	II											III	IV	V	VI	VII	0
			Transition Elements												Nonmetals			
1	1 H Hydrogen																1 H Hydrogen	2 He Helium
2	3 Li Lithium	4 Be Beryllium											5 B Boron	6 C Carbon	7 N Nitrogen	8 O Oxygen	9 F Fluorine	10 Ne Neon
3	11 Na Sodium	12 Mg Magnesium											13 Al Aluminum	14 Si Silicon	15 P Phosphorus	16 S Sulfur	17 Cl Chlorine	18 Ar Argon
4	19 K Potassium	20 Ca Calcium	21 Sc Scandium	22 Ti Titanium	23 V Vanadium	24 Cr Chromium	25 Mn Manganese	26 Fe Iron	27 Co Cobalt	28 Ni Nickel	29 Cu Copper	30 Zn Zinc	31 Ga Gallium	32 Ge Germanium	33 As Arsenic	34 Se Selenium	35 Br Bromine	36 Kr Krypton
5	37 Rb Rubidium	38 Sr Strontium	39 Y Yttrium	40 Zr Zirconium	41 Nb Nicobium	42 Mo Molybdenum	43 Tc Technetium	44 Ru Ruthenium	45 Rh Rhodium	46 Pd Palladium	47 Ag Silver	48 Cd Cadium	49 In Indium	50 Sn Tin	51 Sb Antimony	52 Te Tellurium	53 I Iodine	54 Xe Xenon
6	55 Cs Cesium	56 Ba Barium	57 La Lanthanum	72 Hf Hafnium	73 Ta Tantalum	74 W Tungsten	75 Re Rhenium	76 Os Osmium	77 Ir Iridium	78 Pt Platinum	79 Au Gold	80 Hg Mercury	81 Tl Thallium	82 Pb Lead	83 Bi Bismuth	84 Po Polonium	85 At Astatine	86 Rn Radon
7	87 Fr Francium	88 Ra Radium	89 Ac Actinium	104 Rf Rutherfordium	105 Ha Hahnium													

58 Ce Cerium	59 Pr Praseodymium	60 Nd Neodymium	61 Pm Promethium	62 Sm Samarium	63 Eu Europium	64 Gd Gadolinium	65 Tb Terbium	66 Dy Dysprosium	67 Ho Holmium	68 Er Erbium	69 Tm Thulium	70 Yb Ytterbium	71 Lu Lutetium
90 Th Thorium	91 Pa Protactinium	92 U Uranium	93 Np Neptunium	94 Pu Plutonium	95 Am Americium	96 Cm Curium	97 Bk Berkelium	98 Cf Californium	99 Es Einsteinium	100 Fm Fermium	101 Md Mendelevium	102 No Nobelium	103 Lr Lawrencium

Key

Atomic Number → 6

C ← Symbol of Element

Element Name → Carbon

Solid

Liquid

Gas

CHEM LAB NOTEBOOK

The Chem Lab Notebook is a place to record your experimental results. Use it to keep track of your experiments and to write down interesting reactions. If you keep good records, you will always be able to reproduce any experiment that you try. Write things down as you go along so that you don't forget anything. The notebook is designed to help you organize the information. Most of the information to complete the notebook may be found on the screen, but some, like the formulas for the raw materials, appears in this guidebook.

The next page shows an example of how to fill out the notebook for one experiment.

Chem Lab Notebook

EXPERIMENT # 15 EXPERIMENT NAME: FEED FOR THOUGHT

TARGET NAME: AMMONIUM NITRATE TARGET FORMULA: NH_4NO_3

RAW MATERIALS:

NAME	FORMULA	STATE
SULFUR	S	(S)
SODIUM CHLORIDE	NaCl	(S)
IRON OXIDE	FE_2O_3	(S)
NITRIC ACID	HNO_3	(L)
AMMONIUM HYDROXIDE	NH_4OH	(L)
FLUORINE	F_2	(G)
		( )

COMBINATION: FLUORINE (F_2) + NITRIC ACID (HNO_3)

TOOLS: NONE

REACTION: NITROGEN OXYFLUORIDE + HYDROGEN

COMBINATION: SULFUR (s) + AMMONIUM HYDROXIDE (NH_4OH)

TOOLS: BUNSEN BURNER

REACTION: BOILS - AMMONIUM PENTASULFATE + OXYGEN

COMBINATION: NITRIC ACID (HNO_3) + AMMONIUM HYDROXIDE (NH_4OH)

TOOLS: NONE

REACTION: KABOOM - EXPLODES - AMMONIUM NITRATE - CORRECT!

COMBINATION: Nitrogen , oxyfluoRiDe contact with air

TOOLS: None

REACTION: Blow - up

COMBINATION: sulfur , fluoriDe

TOOLS:

REACTION:

COMBINATION:

TOOLS:

REACTION:

Chem Lab Notebook

EXPERIMENT # EXPERIMENT NAME: the Fizz Biz

TARGET NAME: ______ TARGET FORMULA: ______

RAW MATERIALS:

NAME	FORMULA	STATE
		( )
		( )
		( )
		( )
		( )
		( )
		( )

COMBINATION: carbon(C) + Oxygen(O_2)
TOOLS: Bunsen burner
REACTION: carbon dioxide(CO_2)

COMBINATION: Magnesium + hydrochloric Acid
TOOLS: None
REACTION: magnesium CHLoride

COMBINATION:
TOOLS:
REACTION:

COMBINATION:
TOOLS:
REACTION:

COMBINATION:
TOOLS:
REACTION:

COMBINATION:
TOOLS:
REACTION:

Chem Lab Notebook

EXPERIMENT #　　　EXPERIMENT NAME: ______________________________

TARGET NAME: ______________________ TARGET FORMULA: ______________________

RAW MATERIALS:

NAME	FORMULA	STATE
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		( )
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		( )
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COMBINATION: ______________________________

TOOLS: ______________________________

REACTION: ______________________________

COMBINATION: ______________________________

TOOLS: ______________________________

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COMBINATION: ______________________________

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COMBINATION: ______________________________

TOOLS: ______________________________

REACTION: ______________________________

Chem Lab Notebook

EXPERIMENT # EXPERIMENT NAME: ______________________________

TARGET NAME: ____________________ TARGET FORMULA: ____________________

RAW MATERIALS:

NAME	FORMULA	STATE
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COMBINATION: ______________________________

TOOLS: ______________________________

REACTION: ______________________________

COMBINATION: ______________________________

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Chem Lab Notebook

EXPERIMENT # EXPERIMENT NAME: ______________________________

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Chem Lab Notebook

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Chem Lab Notebook

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Chem Lab Notebook

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EXPERIMENT #   EXPERIMENT NAME: ____________________

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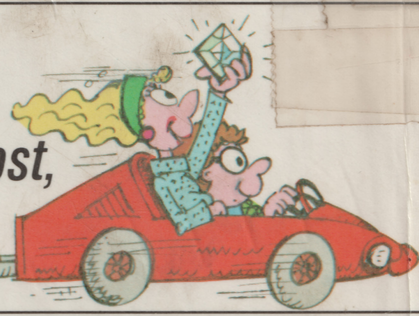
A=01 X=9D Y=22

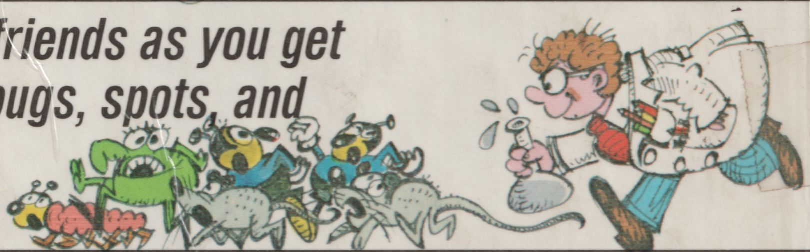
P=34

S=E2

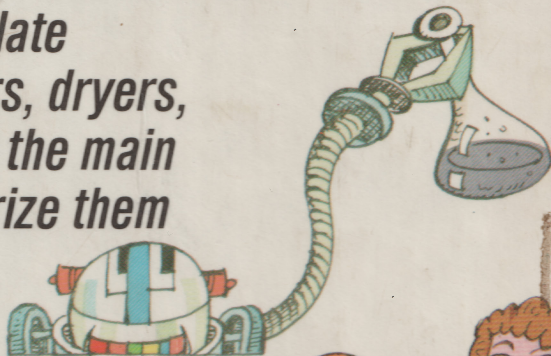
MAKE ***synthetic diamonds, gasoline additives, silicon chips, laughing gas, and vinegar for salads, without the cost, smoke, mess, stink, and bad taste.***



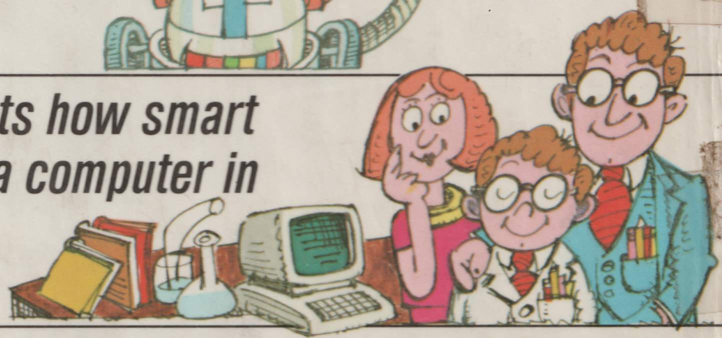
IMPRESS ***your friends as you get rid of rust, rats, bugs, spots, and indigestion.***



USE ***robot arms to manipulate beakers, flasks, condensers, dryers, and Bunsen burners inside the main lab. Superheat and pressurize them in special chambers.***



PROVE ***to your parents how smart <u>they</u> were to buy you a computer in the first place.***



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CHEM LAB

SOFTWARE FOR THE APPLE II+, IIe, IIc, IIGS

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